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Student segregation across and within schools. The case of the Portuguese public school system

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# Student Segregation Across and Within Schools. The Case of the Portuguese Public School System.

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## Abstract

We provide the most comprehensive description of student segregation in the Portuguese public school system to date, a system that exhibits interesting institutional features potentially linked with the student segregation issue (e.g. school catchment areas, course tracking, and almost no central regulations regarding class composition). The analysis uses the entire regular student population enrolled in all public schools of continental Portugal (grades 1 to 12, from 2006/07 to 2016/17). Looking at three segregation dimensions – economic, academic, and immigrant – at both between and within-school levels, and using a novel dissimilarity index recently proposed in the literature aimed at better capturing systematic segregation, we find that segregation, on median, is mild, across time, grades, and regions. The most important exception is the case of within-school academic segregation. During upper-secondary schooling, in particular, when students are divided across classes according to own course-tracking decisions, it doubles. Moreover, within-school academic segregation estimates have the largest interquartile ranges, within a given year, grade, or region, pointing to heterogeneity in the way different schools set up classes internally in terms of students' academic characteristics. Academic and economic segregation are positively associated, at both between and within school levels. The Portuguese segregation insights are also compared to those from other geographies.

Keywords: segregation; dissimilarity index; municipalities; schools; classes

JEL Classification: I24, I38, J15

# 1 Introduction

Contemporaneous societies value knowing how students seat across schools and, within schools, across classes. The accumulated evidence on cognitive and non-cognitive peer effects strongly supports this view (Sacerdote, 2011). Year after year students and parents decide, to some extent, on which school to attend and on which class to bargain for, partly based on those effects (known or perceived). Teachers are also likely pursuing a seat on specific schools and classes partly conditional on actual or expected student composition (Hornig, 2009). On the other hand, knowledge on the distribution of students across and within schools is important to understand what kind of student sorting policies are being implemented by schools and by the relevant local or central governments (West & Wößmann, 2006; Bloom, Lemos, Sadun & Van Reenen, 2015). Such policies must be checked to determine if they conform with societal values related to equity and social inclusion or not, or whether students' quality of education, in particular, and quality of life, in general, might be at risk or not under them. It is then key to supply coherent and extensive measures of student segregation, that is, of how they are unevenly sorted, both across and within schools, so that all major actors of the education system can act upon, and the society in general judge upon, on the actual, real, distribution of students.

Portugal, the country here analyzed, is not an exception to these considerations. The objective of this article is to precisely describe the state of student segregation in Portugal. In doing so, the following research questions will be our focus. Does between and within-school segregation vary over time, grades, and districts? Do between and within-school segregation levels differ from one another? What is the relationship between minority shares and segregation levels, and between different dimensions of segregation? We believe this study provides the answers to these research questions and is able to match them with institutional features of the Portuguese school system.

The empirical analysis uses the dataset compiled by the *Sistema de Informação do Ministério da Educação*<sup>1</sup> (MISI). This student-level administrative database follows all students, from all twelve grades, enrolled in public (state-owned, state-managed) schools in continental Portugal, throughout an entire decade (2006/07 – 2016/17). Given information on the actual classes and schools students were placed in, and on the schools' location (namely the municipality where they are located), we are able to analyze student segregation at two distinct levels: between-schools (within-municipality), and within-schools (across classes of the same grade). For each of these levels we look at three segregation dimensions, each stemming from specific students' dichotomous characteristics: economic (low-income vs non-low-income), academic (at least one retention vs no retentions), and immigrant (born abroad or with at least one parent born abroad vs all three not born abroad). Segregation is measured with the density-corrected dissimilarity index ( $D_{dc}$ ) recently proposed by Allen, Burgess, Davidson, & Windmeijer (2015) to capture systematic segregation more robustly than the classic dissimilarity index ( $D$ ).

Our main findings are that (1) there is a substantial increase in within-school academic segregation (and just a modest one for within-school economic segregation), during upper-secondary as compared to previous grades; (2) between-school segregation varies somewhat *across* primary, upper-primary, lower-secondary, and upper-secondary, but much less across grades *within* each of these stages; (3) over time, all segregation dimensions, at both between and within-school levels, exhibit time-invariant mild levels, with the case of within-school academic segregation presenting the highest values; (4) regional differences are more marked in terms of between-school segregation rather

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<sup>1</sup> Information System of the Ministry of Education.

than within-school, with the municipalities belonging to the districts of Lisboa and Setúbal (the country's capital area) exhibiting the relative highest (and most precisely estimated) levels of unevenness in the way students are placed across schools; and (5) there is a mild positive association between academic and economic segregation, at both between and within-school levels (after netting-out several confounding factors). These are important findings as they indicate that academic, and to a lesser extent economic, characteristics of the students correlate with their observed placement, both between and within schools. Immigrant status of students also correlates with their placement, but this dimension does not seem to present higher segregation levels than the other two dimensions analyzed.

We show that certain characteristics of the Portuguese public education system seem to explain (up to a certain degree) the patterns found. Namely, (1) the upper-secondary tracking regime for the differing segregation levels before and after grade 10; (2) the differing granularities of the networks of primary, upper-primary, and lower and upper-secondary schools combined with the existence of school-catchment areas for the differences in between-school segregation levels across those educational stages (and districts); and (3) the vagueness of central regulations regarding class composition for within-school segregation patterns in general.

Domestic and international researchers and analysts will value this paper for the following three contributions. First, it offers a comprehensive and coherent study of the student segregation phenomena across what seem to be the main dimensions and levels of analysis usually adopted in the school segregation literature (economic, academic, immigrant; between and within schools), for the same country and period. To our knowledge, this is rare in the literature with past studies more often providing analyses restricted to fewer combinations of dimensions/levels of segregation. Although quite likely due to perfectly legitimate reasons such as researchers' own research interests or limited data availability, the apparent scarcity of studies offering a more overarching type of analysis, such as the one we present here forces any interested reader to compare evidence related to different kinds of segregation from different sources. Due to differences of regions, periods, and idiosyncratic data treatment procedures likely found across them, comparability may be less straightforward, something that we believe to be avoided in this work (Conger, 2005, is an interesting example of another comprehensive study of segregation in terms of offering both a between and within-school analysis, though merely dedicated to the immigrant/racial dimension, see Table 1).

Secondly, it uses almost the entire student population of a European country throughout more than a decade, which also is uncommon in the literature (Allen & Vignoles, 2007, is a similar example for England, 1989-2004, see Table 1). Lastly, the Portuguese public education system likely contains characteristics similar to those located in other geographies and economies, meaning that similar segregation patterns might be at work there (e.g. Mediterranean Region, and Latin America). The Portuguese case may then be a useful reference point.

The following Section reviews the literature related with three important topics for this study: (1) the broad peer effects, (2) the methodology to measure segregation, and (3) studies on segregation or related subjects devoted to the Portuguese case and to that of other geographies to better highlight the contributions of this paper. Section 3 details the institutional context of the Portuguese education system, namely features related to the allocation process whereby students are placed across schools and classes. Section 4 presents the data. Section 5 discusses the actual methodology employed to measure segregation. The segregation estimates are provided in Section 6. Section 7 concludes.

## 2 Literature Review

One of the main reasons why student segregation is of concern has to do with the suspicion that similar students placed in schools or classes with different types of peers may lead those students to adopt different behaviors that otherwise they would not. Different behaviors are likely tied to different outcomes (educational or other) meaning that different segregation patterns are potentially linked to unequal educational or life opportunities.

In this regard, the economics of education peer effects literature has been gradually establishing the causal relationship between exposure to certain types of peers and individual students' outcomes, Sacerdote (2011), though some uncertainties remain regarding magnitudes and non-linearities of the effects. Exposure to higher achieving peers, in particular, has been argued to be incremental to individual cognitive outcomes, especially for individuals in the bottom of the achievement distribution. On this, some interesting studies employing large administrative datasets (fixed effects estimations) are Hanushek, Kain, Markman & Rivkin (2003); Sund (2009); Lavy, Silva and Weinhardt (2012); Arcidiacono, Foster, Goodpaster & Kinsler (2012); and Burke and Sass (2013). The last two of these also present evidence that peer effects are more intense in specific disciplines (requiring more collaborative work) and at the class rather than at the school-grade level. Importantly, Burke and Sass (2013) demonstrate that the peers' ability effect on individual performance is sensitive to the initial achievement level of the student in a non-monotone way (i.e. it is incremental to be exposed to academically gifted peers, but not with peers who are much more gifted relative to own baseline level). Applying instrumental variable strategies, Lefgren (2004) and De Giorgi, Pellizzari, & Woolston (2012) provide more evidence on peers' ability positively impacting individual outcomes, though faintly, as well as on classroom ability heterogeneity (no heterogeneity meaning total segregation in academic ability) having an inverse U-shaped relationship with individual performance (thus suggesting the existence of an optimal strictly positive level of class ability heterogeneity). Contrasting with the De Giorgi et al. (2012) study, Duflo, Dupas, & Kremer (2011) offer experimental evidence supporting the view that increasing the percentage of top achieving classmates positively influences *all* students within the school. Meaning that sorting students across homogeneous classes (according to previous academic achievement) would be the desirable policy.

The effects of racial peer composition on student achievement has also been examined, though more often in the context of USA schools. For example, Hoxby (2000); Angrist & Lang (2004); and Hanushek, Kain, & Rivkin (2009) find that peer effects are stronger intra-race and that larger shares of black students negatively affect black students, with no significant reciprocal effect on whites. Hoxby (2000) also deals with gender peer effects.

Looking at the Portuguese case, Firmino, Nunes, Reis, & Seabra (2018), find preliminary evidence that for Portuguese students (grades 5 through 9), too, there seem to exist important classroom peer effects, namely a negative impact from sharing the classroom with low-income students. In line with this, Seabra, Carvalho, & Ávila (2019) also document a negative effect from exposure to larger concentrations of low SES students in Portugal (4<sup>th</sup> graders), at the school-grade level, especially for African descendent students.

Some studies have examined peer effects beyond those related to pure academic achievement. Verkuyten & Thijs (2004) document a negative relationship between the class proportion of non-foreigners and foreigner students' self-esteem, in the Netherlands. In the USA, analyzing the Moving to Opportunity program, which diminished economic segregation across neighborhoods by displacing low-income families to less impoverished zones in the cities, Ludwig, Duncan, Gennetian, Katz, et al. (2013) make the case that growing up in less impoverished

neighborhoods builds up subjective well-being, especially for low-income students, while Chetty, Hendren, & Katz (2016) document better long-term outcomes (higher chance for college enrollment, higher labor market earnings, and lower single parenthood rates) for sufficiently young moving children.

From the perspective of what might cause a non-random allocation of students, Bosworth (2014) interestingly documents empirical evidence supporting that classroom assignment is driven by students' observables. Students' characteristics are likely to be taken into account when it comes the time to decide on their distribution across classes, within any given school. Agents such as school authorities and parents likely try to optimally place them according to their specific preferences and goals, possibly to reap the benefits and avoid the costs from exposure to certain types of peers. Still on this topic, Levy & Razin (2017) present a theoretical model showing that due to a learning failure while in the labor market, repeating generations of parents may persist with different beliefs regarding which the best school might be (the most productivity-enhancing school) to send their children to, thus perpetuating segregation, even if there are no real differences between schools in terms of the value added accrued to students (i.e. to their offspring, the next generation of parents).

Turning to the topic of segregation measurement, several metrics have been proposed in the literature in past decades, see Frankel & Volij (2011) for a review. One sees at least three main sets of measures: group interactions/exposure, diversity, and unevenness (OECD, 2019).<sup>2</sup> Measuring group interactions relies on estimating the likelihood that one member of one group comes into contact with members of (an)other group(s) (e.g. the exposure index, or its normalized version). Measuring diversity seeks to estimate how many different groups are represented within a given statistical unit, e.g. a school, see Reardon and Firebaugh (2002) and Frankel & Volij (2011) for recent theoretical and empirical applications on this. One possible example within this set of measures is the mutual information/entropy index. The third set of measures may be labeled as estimators of departures from evenness (with respect to the distribution of members belonging to one of two possible groups across statistical sub-units forming a wider unit, e.g. across classes within schools, or across schools within a geographical region).

Duncan & Duncan (1955) showed that many unevenness measures, for example the popular dissimilarity index ( $D$ ) and the Gini coefficient ( $G_i$ ), form a family of indexes related to the analysis of the segregation curve. Despite Massey & Denton (1988) claiming, based on factor and principal component analyses, that the dissimilarity index should be adopted as the reference within the set of unevenness measures, it too has been subject to criticism. Cortese, Falk, & Cohen (1976) noted that  $D$  uses as reference point the evenness scenario ( $D = 0$ ), whereas researchers might be more interested to compare observed levels of segregation to the case of random allocation of individuals to units. Insofar as randomness in allocation generates expected strictly positive levels of unevenness ( $D > 0$ ), it might be more informative to know by how much the observed distribution of individuals adds, in terms of unevenness, to that expectation and not to the eventual randomness-inconsistent case of complete evenness. Based on this insight, Carrington & Troske (1997) formulate another segregation index capable of measuring unevenness above (which would be seen as segregation) and, theoretically, also below (which would then be seen as inclusion) the expected level of unevenness consistent with randomness. On the other hand, the dissimilarity index has the virtue of not

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<sup>2</sup> Residential segregation literature conveys five types of measures: *evenness*, *exposure*, *concentration*, *centralization*, and *clustering* (Massey & Denton, 1988). The last three types convey information regarding the spatial nature of segregation, which is not focused on this paper, so we take the first two and add *diversity* as the main contenders for our purposes.

depending mechanically on the minority share (at least under not too extremely small values of the minority share). This is convenient for comparisons of different statistical units with potentially different minority shares.

The Gorard index ( $G$ ) (Gorard & Taylor, 2002) and the current concentration index ( $CC$ ) (OECD, 2019) are other possible measures of segregation that happen to be sensitive to the minority share.<sup>3</sup> The Gorard index, in particular, has been shown by Allen & Vignoles (2007) to not likely be the best choice (as compared with a segregation curve index such as  $D$  or  $Gi$ ) to analyze segregation across schools given the potential large variations in minority shares across them (besides presenting other technical drawbacks such as not being 0-1 bounded, nor being symmetric). The square-root index is yet another segregation index proposed in Hutchens (2001) and Hutchens (2004). Although the square-root index satisfies seven important properties, the dissimilarity index satisfies five of these, failing only at two related with the ability to aggregate and with additive decomposability (see note 2 in Allen & Vignoles, 2007; we will elucidate these five properties of  $D$  in Section 5).

More recently, Allen et al. (2015) offer several correction procedures to the dissimilarity index in order to make it a measure of systematic segregation. The corrections aim to, precisely, partial-out the “bias” of strictly positive levels of unevenness that may be coherent with random allocation. These bias-adjustments are more intense whenever the fundamental parameters of unevenness segregation – minority share and unit sizes – are very small, which are the ones more likely to exacerbate  $D$  even under a random underlying allocation process. It is one of the bias-corrected dissimilarity indexes supplied in this last reference the one employed in this article to measure segregation, namely their density-corrected dissimilarity index ( $D_{dc}$ ).

As far as we are aware, there are no available analyses related to student segregation in Portugal, at least not comparable to the scope and magnitude of what we present here. Some studies look at specific types of students that are usually of interest to segregation analyses, such as those with immigrant background, e.g. Marques, Rosa, & Martins (2007), Hortas (2013), Roldão (2015), or those with specific ethnic background (e.g. Gypsy/Roma students, see Abrantes, Seabra, Caeiro, Almeida, & Costa, 2016; and Araújo, 2016). However, these do not delve into formal segregation analysis, but rely instead on describing socioeconomic contexts and their relationship to student achievement. Moreover, most of these studies employ methodologies such as the case-study or personal interviews that, in spite of offering a deep perspective on the few cases analyzed, fail to provide a comprehensive view of the phenomena (i.e. they lack external validity).<sup>4</sup> Central authorities have, to date and to the extent of our knowledge, produced one study on student segregation: Baptista & Pereira (2018). However, this work merely analyzes between-school economic segregation (within-districts; continental Portugal), only for 5<sup>th</sup> and 6<sup>th</sup> grade students (out of twelve

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<sup>3</sup> OECD (2019) provides the exact mathematical relationship among these indexes and the dissimilarity index:  $CC = 2pG = 2p(1 - p)D$ , with  $CC$ ,  $G$ , and  $D$ , as the indexes, and  $p$  as the minority share.

<sup>4</sup> The Abrantes et al. (2016) and Araújo (2016) studies on Gypsy students are quite representative on this with the former focusing on one single public primary school in Lisboa, and the latter on another single public primary school in a rural area of Portugal. Nevertheless, they document extremely interesting insights. The former reports an outstanding 80% of the school population belonging to that single ethnic group, and with Gypsy parents reporting that they tend to be informally barred from enrolling their children in neighboring public primary schools. The latter documents a case of (total) white-flight from the school analyzed immediately after Gypsy parents started enrolling their children there. These constitute signs of strong ethnic between-school segregation (at least across primary schools) that, unfortunately, are impossible to extrapolate much further beyond those particular schools. Present Portuguese legislation prevents generalized collection of racial or ethnic information, which, understandably, forces researchers to apply case-study type of methodologies. Our dataset is not an exception. We are unable to study the between/within-school sorting of any ethnic/racial type of student. Hopefully, future versions of the database will provide more information regarding student ethnicity and/or race to allow fully understanding these phenomena and their real extent.

grades in total) and for the single 2015/16 school-year. Using a segregation measure describing the average difference between all possible pairs of schools (within a given district) in terms of proportion of low-income students, they find that schools situated in the most urban and populated districts such as Lisboa, Porto, and Setúbal (Map A1, Appendix A) exhibit the highest levels of economic segregation. In turn, Justino, Santos, Beatriz, Gramaxo et al. (2017) map a series of indicators related to students' socioeconomic status, achievement levels, and teacher characteristics for all municipalities and schools of continental Portugal. Among their conclusions two relate closely with the analysis we present here: (1) immigrant students tend to be concentrated in municipalities/schools of the Lisboa metropolitan area and of Algarve (southernmost Faro district), and (2) they suggest that there is between-school economic segregation, especially in the most urban municipalities. Unfortunately, they do not provide formal segregation statistics. Finally, the interesting work of Bêa (2018) is, perhaps, the closest exercise that exists to ours. Bêa uses the same administrative database across the same school-years as we do, but looks only at between-school segregation, just within the municipality of Lisboa, only across primary (1<sup>st</sup> cycle) schools, and uses the classic *D*. Her main findings are that economic and immigrant between-school segregation levels in Lisboa seem to have been relatively high in the last decade. More specifically, Bêa estimates that around 40% of low-income and immigrant students would need to change from their current schools to another one in the city so that their distribution across Lisboa's primary schools would be completely even.

Table 1 summarizes some of the empirical literature on student segregation since the early 2000s and compares several aspects with the present study. Despite not being an exhaustive list of all past studies on the topic we believe it suggests the Portuguese case we offer here expands the existing evidence in a number of aspects: (1) it is a non-Anglo-Saxon case encompassing the entire student population (grades 1 through 12) of a Southern European country; (2) it provides an overview of student segregation throughout a full recent decade; (3) it supplies a variety of combinations of different dimensions (economic, academic, and immigrant) and of distinct levels of analysis (between and within-school, the latter being the rarest in the related literature) of student segregation for the same education system, as well as a study on the structural correlations between all combinations of dimensions/levels of segregation and respective minority shares; and (4) uses the relatively recent density corrected dissimilarity index (Allen et al., 2015) as a more robust metric to measure segregation.

Finally, there are other important topics related to the student segregation topic in general that we should mention, though we will not delve into them here. One is that of quantifying the social welfare impact brought about by the uneven distribution of students across entities like schools or classes. We point to the Río & Alonso-Villar (2018) contribution as a clear methodological advance in this regard. The other is whether observed student segregation might be counteracted (or exacerbated) by students themselves. Holfve-Sabel (2015) presents the interesting case of Swedish 6<sup>th</sup> graders who seem to offset, at least partially, within-school immigrant segregation through their inclusive decisions about whom to work with during lessons.



Table 1 – Sample of Papers with Empirical Results on Student Segregation

<i>Panel I</i>		Gorard & Taylor (2002)	Conger (2005)	Allen & Vignoles (2007)	Frankel & Volij (2011)	Bartholo (2013)	Allen et al (2015)	Gutiérrez et al (2017)	Béa (2018)	Murillo & Martínez-Garrido (2018)	OECD (2019)	Present Study
Segregation Index												
MI (mutual information)	D	✓		✓	✓ <sup>1</sup>	✓	✓	✓ <sup>4</sup>	✓		✓	
	Ddc						✓					✓
	G	✓				✓				✓		
	S (exposure)		✓							✓	✓	
Level of Analysis												
Between-school												
	within-nation	✓		✓	✓			✓		✓	✓	
	within-state				✓ <sup>2</sup>					✓		
	within-CBSA				✓ <sup>2</sup>							
	within-school district		✓		✓ <sup>2</sup>							
Within-school	within-municipality					✓			✓			✓
	within-parish								✓			
	within-LEA			✓			✓					
	across-classes		✓									✓
Dimensions of Segregation												
Socioeconomic												
beneficiary of poverty alleviation	free(or reduced price)-school-meal	✓		✓			✓		✓			✓
	parents' education					✓			✓ <sup>6</sup>			
	income transfer					✓		✓ <sup>5</sup>		✓ <sup>5</sup>	✓ <sup>5</sup>	
	SES											
Racial/Ethnic	Academic										✓	✓
	Immigrant		✓						✓			✓
	Racial/Ethnic		✓		✓	✓						
Correlation Analysis												
among segregation indexes (same segregation dimension/level of analysis)					✓	✓	✓ <sup>3</sup>	✓		✓ <sup>3</sup>		
	among segregation dimensions										✓	✓
	among segregation dimensions and minorities											✓
Type of Data	Administrative dataset	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
	LSIA										✓	✓

<sup>1</sup>also Atkinson, Gini, Exposure, Entropy; <sup>2</sup>cross-section analysis of 2006/07; <sup>3</sup>implicit; <sup>4</sup>and Hutchen's Square Root Index; <sup>5</sup>PISA ESCS; <sup>6</sup>also residential segregation

Table 1 – Sample of Papers with Empirical Results on Student Segregation

<i>Panel 2</i>		Gorard & Taylor (2002)	Conger (2005)	Allen & Vignoles (2007)	Frankel & Volij (2011)	Bartholo (2013)	Allen et al (2015)	Gutiérrez et al (2017)	Bêa (2018)	Murillo & Martínez-Garrido (2018)	OECD (2019)	Present Study
Grades	Primary				✓				✓			
	1		✓			✓						✓ <sup>9</sup>
	2					✓						✓ <sup>9</sup>
	3					✓						✓ <sup>9</sup>
	4					✓	✓					✓ <sup>9</sup>
	Upper-Primary				✓							
	5		✓			✓						✓
	6											✓
	Lower-Secondary				✓							
	7											✓
	8											✓
	9							✓		✓	✓	✓
	Upper-Secondary		✓		✓							
	10											✓
	11											✓
	12											✓
Geography												
UK		✓ (Wales)		✓ (England)			✓ (England - especially inner-London LEAs)					
USA			✓ (NYC school district)		✓ <sup>7</sup>							
Portugal									✓ (Lisboa)			✓
Brazil						✓ (Rio de Janeiro)						
Spain										✓ <sup>8</sup>		
PISA participating countries								✓		✓ (European Union countries)	✓ (71 countries/regions)	
Period		1989-1996	1995; 2000	1989-2004	1987; 2007	2004-2010	2006	2000; 2003; 2006; 2009; 2012; 2015	2007-2017	2015	2015	2007-2017

Notes: Periods separated by ‘-’ means whole range of years was analyzed; singular years analyzed separated by ‘;’.  
<sup>7</sup>public schools operating across studied years; <sup>8</sup>whole country and autonomous communities; <sup>9</sup>between-school segregation

### 3 Institutional Context

The Portuguese education system groups 12 sequential grades in four cycles across five main types of school (Table A1, Appendix A).<sup>5</sup> Pupils aged 5 (minority) or 6 (majority) years-old begin the 1<sup>st</sup> cycle at grade 1 and complete it at the end of grade 4. Students enrolled in grades 6 and 9 finish the 2<sup>nd</sup> and 3<sup>rd</sup> cycles, respectively. Upper-secondary – containing grades 10 to 12 – constitutes the final cycle of studies before labor market or college.

The five types of school operating within the public system offer different combinations of cycles. Type-1 schools provide grades 1 to 4 and these grades can only be offered by such schools. Type-2 schools offer both 2<sup>nd</sup> and 3<sup>rd</sup> cycles, spanning grades 5 to 9. Type-3 schools have students from cycles 2 to 4 (grades 5 to 12). Type-4 schools supply cycles 3 and 4, i.e. grades 7 to 12. Finally, type-5 schools offer only grades 10 to 12, i.e. only cycle 4.

Schools receive enrollment requests which they must then accept or reject according to criteria defined by the central government. When total enrollment requests to a given school are less than that school's capacity there is no need to decide which students are allowed to enroll or not since the school has capacity to accept everyone. However, when demand for a school seat exceeds the school's capacity an ordered list of criteria must then be followed to assess which applicants are given a place at the school. A simple summary of that list of criteria is as follows: (1) whether the student has a special education need, (2) whether the student was enrolled in that school in the previous year, (3) whether the student has a sibling enrolled in that school, (4) whether the student is recipient of socioeconomic support, (5) whether the student resides in the school catchment area, (6) whether a parent works in the school catchment area. This list of tie-breaks varies somewhat from cycle to cycle, and across school-years, with some criteria moving up or down one or two positions. In spite of possible variations of a criterion's position, it shows that residential segregation may translate to between-school segregation given that residency impacts the school acceptance scheme both directly through criterion (5), as well as indirectly through criterion (4) as families tend to cluster in neighborhoods of relatively homogenous socioeconomic conditions (e.g. Malheiros & Vala, 2004 report clear spatial residential segregation patterns across parishes and neighborhoods belonging to the metropolitan area of Lisboa with respect to persons with a foreign nationality; this, in turn, may correlate with socioeconomic status).

Classes are usually maintained unchanged throughout all grades within a given cycle, by schools, hence school-induced segregation of students within-schools, across classes, should be more intensely observed at the *beginning* of each cycle (if any occurs). Especially if the beginning of the cycle coincides with moving to a new school. Specifically, these cases refer to students enrolling in grade 1 (always into a type-1 school), in grade 5 (always into type-2 or type-3 schools), in grade 7 (several possible school-move combinations between school types 2, 3, and 4), and in grade 10 (several possible school-move combinations between school types 2, 3, 4, and 5). There are two main exceptions: (i) students repeating a given grade who are displaced from their current class and reassigned to one of

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<sup>5</sup> From 2009/10 on, mandatory schooling was enlarged to encompass upper-secondary. Under this new regime, students are legally entitled to leave the education system (if they want so) only as soon as at least one of the following two conditions is true: (1) turning 18 years-old, or (2) having finished 12<sup>th</sup> grade. By contrast, the previous regime was mechanically the same, differing only in the thresholds: 15 years-old for condition (1), or completing 9<sup>th</sup> grade for condition (2). The new thresholds regime was enacted upon all students whom, by 2009/10 enrolled in 7<sup>th</sup> grade. By 2014/15 all students from all 12 grades were subject to the new regime. We should mention that although within the Portuguese public schooling system upper-secondary schooling is not formally called “4<sup>th</sup> cycle” (it is best known as *secundário*), we do so here for expositional simplicity.

the newly promoted classes of the grade they have to repeat (mixed-grade classes are only found in type-1 schools and for this reason we do not compute within-school segregation measures for grades 1 to 4; we come back to this issue when discussing the segregation measure used); and (ii) students moving from one school to another within a given cycle, or even within a given grade in the middle of a given academic year.

Whereas between-school sorting of students is clearly regulated whenever schools receive more enrollment requests than capacity, within-school (across classes) sorting of students, during the whole period considered, was quite vaguely regulated by the public authorities (see CNE, 2016 for a review on the evolution of legislation concerning class size and composition). In general, schools were mandated by law to translate each school-grade-year specific student heterogeneity across the respective classes, however with no concrete quantitative bounds on what it means to comply with that heterogeneity.

The Portuguese system contains a regular academic track and other tracks related to vocational education and other alternative educational paths. The regular track is by far the most demanded and we consider only these students.<sup>6</sup> Further, regular academic track students are required to choose one specific upper-secondary level course when enrolling in grade 10 with the general options available being (1) exact sciences, (2) socio-economic sciences, (3) humanities/languages, and (4) arts/music (it may be the case that some schools may offer only a subset of these). Upper-secondary schools' classes, in general, group students that opted for the same upper-secondary course.

Finally, it is important to mention that there have been changes during the period here considered in the way students can gain access to socioeconomic aid (which combine multiple discounts, such as reduced prices on school meals, transports, and textbooks). Whether students gained access to such discounts determines which ones we consider to belong to a low-income household. Although throughout the period analyzed the main philosophy behind the granting of the discounts has been constant – access conditional on sufficiently low per capita income at the household level – in 2008/09 there were two major changes (which were maintained until the last year of the dataset used). First, the determination of families' income levels ceased to be done at the school level and became directly linked to their family allowance category (determined by the central government).<sup>7</sup> Second, the income thresholds to accept a given family into one of the two major socioeconomic support levels, A and B, were relaxed. These two changes induced an increase in the proportion of students taking both levels, namely level A (the one we use as reference). We present the increase of the share of low-income students in the next Section, which details the dataset used.

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<sup>6</sup> Although we focus on segregation of students of the regular academic track across schools and across classes, we recognize that segregation of students across educational tracks is an interesting case for future analysis.

<sup>7</sup> The formula to determine families' income up to 2007/08 was regulated by the central government and thus common across them. However, the incumbency to check the veracity of each of the formula's components (gross family income, health and housing expenditures, taxes and social security payments, and number of children) was on the local school side. The common perception, up to 2007/08, was that in the end this process gave schools the possibility to exert different levels of effort in checking the correctness of those figures, or that different schools with different administrative resources could act differently whenever doubts regarding the figures reported by families were raised. The 2008/09 reform was partly justified to make the process fairer to all families in the country in the sense that *per capita* income levels became determined by a central government procedure instead of being determined/confirmed at the local school level.

## 4 Data

The database used is *MISI* dataset, which is an administrative dataset collected by the Portuguese Ministry of Education. We use information on all students enrolled in public schools (in the regular academic track), in continental Portugal<sup>8</sup>, from grades 1 to 12, and from 2006/07 to 2016/17. In other words, the majority of students enrolled in the Portuguese public educational system throughout more than a decade. Table A2 (Appendix A) details the actual shares of students enrolled in the regular academic track and in public schools by cycle over time. In short, students enrolled in that track and, simultaneously, in public schools, comprise the large majority across cycles 1 through 3, and roughly half during upper-secondary (cycle 4). This information set is quite comprehensive, spanning, per year and on average (pooling all grades), around 1 million individual students, over about 5000 different schools, across all 278 municipalities of continental Portugal. Unlike earlier studies focused on the Portuguese case, external validity of our results should, in principle, not be an issue of concern (see discussion in Section 2).

Several students' characteristics are available, as well as about their parents. In order to compute the measures of segregation we use information with respect to student and respective parents' place of birth, whether the student belongs to a low-income household, and students' age. From these characteristics we compute three dichotomous variables: *low-income*, *at least one retention*, and *immigrant*. Pupils with at least one retention are defined as those whose age is strictly *greater* than the maximum expected age at the beginning of the academic year (set to September 15<sup>th</sup>), making it an approximation to true retention. In turn, the maximum expected age is the maximum age the student may be observed with, at the beginning of the academic year, given the current grade she is enrolled in, under the scenario of not recording any retention since grade 1. These limiting ages start at 7 years old for 1<sup>st</sup> graders and increment by one year of age for each grade, so, by the 12<sup>th</sup> grade, it is 18 years old. Note that these are exact ages, so if a student is, say, 17.1 years old by September 15<sup>th</sup> and is enrolled in grade 11, then this student is given the status of having at least one retention. Not doing so would imply that the student had entered grade 1 aged 7.1 years old, which is not permitted. As explained in the previous Section, students must enroll in grade 1 aged 6 years old (or even 5 years old if they turn 6 between mid-September and December 31<sup>st</sup>), but not 7 or more.<sup>9</sup> In turn, students are given the status of belonging to a low-income household if they benefit from the most intense level of socioeconomic support at school (level A), the one allowing free school meals. The last dichotomous variable –

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<sup>8</sup> Students from the Atlantic islands' autonomous regions of Azores and Madeira are not observed in the dataset.

<sup>9</sup> The inconvenience of approximating true retention status via comparison of actual and (maximum) expected age is to erroneously not attribute such status to a group of students that, by grade  $g$ , possess, simultaneously, two characteristics: to only have been truly retained once between 1<sup>st</sup> grade and grade  $g$ , and, to have been enrolled in grade 1 aged strictly less than 6 years-old. The incidence of that error, however, is likely to be small. Note the following: (1) only around 29% of total students are born between 15<sup>th</sup> September and 31<sup>st</sup> December of any given year; (2) Madeira, Reis, Nunes, & Seabra (2018) state that, on average across school years, about 80% of students born between 15<sup>th</sup> September and 31<sup>st</sup> December enrol aged less than 6 years old (some parents opt to defer students' entry age); and (3) Ikeda & García (2014) document, for Portugal, the actual retention rate is around 35% (percentage of 9<sup>th</sup> grade students reporting *at least one* retention – larger than the percentage of students with *exactly one* retention, PISA 2009 data). Multiplying all three percentages shows that only about 7% of the students in our dataset may have been given an erroneous retention status. Actually, the 7% figure is an upper bound of the true error incidence. As soon as some students of this particular group record a second, true, retention, then our approximation is again correct. On the bright side, our choice to not use true retentions, and instead an approximation, has the benefit that it is computable for *all* students. Even those that move from/to private schools or migrate. It does not rely on the ability to follow them over time, to then infer retention events by comparing grades in consecutive school-years within the student panel (which is not possible if within the student panel there are blanked school-years due to being enrolled in a school outside the continental Portugal public school system, e.g. a private school, or a school located in the Atlantic islands' autonomous regions or in another country).

*immigrant* – attains value 1 if the student, or her mother, or her father, was not born in Portugal (if at least one of these three persons has missing information regarding place of birth then it counts as a missing observation).

The use of most of these dichotomous variables is not uncommon in school segregation analysis, and they are also endowed with some practical virtues. Proxying economic status via free school meal status seems the best alternative to us, as it has no missing observations, whereas other variables present in our dataset, such as parent education, parent job status, and parent occupation, do possess non-marginal amounts of missing information (there is no information on parent wage or actual household income). Allen & Vignoles (2007), Bartholo (2013), Allen et al. (2015), and Bêa (2018) use similar or exactly the same dichotomous variable to identify low-income students. Alternatively, Murillo, & Martínez-Garrido (2018) and OECD (2019) identify them as those below certain percentiles of the ESCS socioeconomic index distribution (PISA data). This alternative, however, is not suited for our setting as an equivalent socioeconomic index is not present in the dataset and computing it based on parental related variables would run into the missing information problem.

Identification of immigrant status of the student varies somewhat across studies, possibly depending on data availability on students' (and parents') nationalities and places of birth. For example, Bêa (2018) and Conger (2005) use only the students' nationality and place of birth, respectively. Because we also possess information on parents' place of birth we can identify as immigrants those also belonging to the second generation, which may well be subject to similar segregation pressures as first-generation immigrants.

The division between students with at least one retention from those recording none may be the least common way to distinguish low-achievers from other students. Alternatively, OECD (2019) categorizes as low-achievers those scoring in the bottom quartile of the PISA achievement distribution. Such a procedure in our setting is not impossible to implement as the dataset does possess students' scores on national exams and on school-internal evaluations per subject. However, both sets of scores have serious drawbacks for our purposes in this study (besides also presenting non-marginal amounts of missing cases whenever such information is expected to exist). On one hand, the external scores are specific to certain grade/school-year combinations, which consequently precludes us from computing segregation estimates for students enrolled in combinations with no external exams.<sup>10</sup> On the other hand, the potential lack of comparability of school internal marks across teacher-by-school-by-school-year combinations (internal marking is a subjective exercise likely to be driven by factors that differ across these cells) makes it a doubtful exercise to identify any given student as top or low-achiever in a definite way using such marks. Because this is a necessary step to compute segregation estimates, a clean interpretation of the latter would be jeopardized if one were to use the former scores. We thus view the distinction between students with (approximated) zero or at least one retention as a reasonable way to distinguish students with different educational outcomes (with that distinction being reasonably coherent across school-years, grades, and places), while also implementable for the entire dataset.<sup>11</sup>

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<sup>10</sup> During the period of our dataset only 9<sup>th</sup> and 12<sup>th</sup> graders possess, for every school-year, external scores. Fourth and 6<sup>th</sup> graders have such scores only for a subset of all school-years. All remaining grades possess no external scores for the period covered.

<sup>11</sup> We recognize that working with this variable has the drawback of not being able to compute academic segregation estimates for 1<sup>st</sup> graders, as these are not traditionally subject to retention. However, this is less restrictive than computing such estimates for 12<sup>th</sup> and 9<sup>th</sup> graders alone (and just some 4<sup>th</sup> and 6<sup>th</sup> graders' cohorts). Such estimates should also be more coherent than academic segregation estimates based on internal scores, as different teachers may agree on an overall retention status more quickly than on specific marks for any particular student.

The *MISI* dataset also provides information on school and class membership for each student, as well as schools' locations (district and municipality), for each academic year.<sup>12</sup> This information enables us to compute the segregation measures both between schools (within municipality) and within schools (across classes of the same grade).

Figures A1 through A5 in Appendix A decompose the three minorities' shares over time, across grades, across districts, across cycles over time, and across regions<sup>13</sup> over time, respectively. In each Figure the first and second-row graphs display the median shares of minorities taken from municipality-grade-year and school-grade-year distributions, respectively.<sup>14</sup> As remarked at the end of the previous section, the increase in the share of low-income students is visible in the top left graphs of Figures A1 and A4. Around 5 p.p. comparing municipality-grade-year cases from 2008/09 with the two previous school-years in the former, and around 5 to 10 p.p. depending on the cycle for the latter. The bottom graphs of Figures A1 to A5 do not pool school-grade-year cases from grades 1 – 4 due to mixed-grade classes, and the medians thus do not take these into consideration; this explains why top and bottom graphs show slightly different patterns.

## 5 Methodology

As mentioned in the literature review, segregation has been measured through the dissimilarity index  $D_{ugt}$ :

$$D_{ugt} = \frac{1}{2} \sum_{s=1}^{S_{ugt}} \left| \frac{minority_{sgt}}{Minority_{ugt}} - \frac{majority_{sgt}}{Majority_{ugt}} \right| = \frac{1}{2} \sum_{s=1}^{S_{ugt}} |\hat{p}_{sgt}^1 - \hat{p}_{sgt}^0| \quad (1)$$

for statistical unit  $u$  (statistical sub-units  $s$  nested within  $u$ ), at grade  $g$ , and time period  $t$ . In our case, the statistical units will be the municipalities for the between-school segregation measures and the schools for the within-school ones. The corresponding statistical sub-units will be the schools for the former, and the classes for the latter.  $S_{ugt}$  is the appropriate total number of schools (classes) observed in the municipality (school)  $u$ , in which there are students of grade  $g$ , in period  $t$ . The index is then half of the summation (over all  $S_{ugt}$  sub-units  $s$  of  $u$ ) of the absolute differences between the proportions of minority and majority students found in a given sub-unit  $s$ ,  $\hat{p}_{sgt}^1 = \frac{minority_{sgt}}{Minority_{ugt}}$  and  $\hat{p}_{sgt}^0 = \frac{majority_{sgt}}{Majority_{ugt}}$ , respectively. Note that these proportions measure the incidence of each group of students, found in a given sub-unit, relative to each group size at the unit level, *not* the share of each type of student in that sub-unit relative to the sub-unit's size. Accordingly,  $minority_{sgt}$  ( $majority_{sgt}$ ) is the number of minority (majority) students found in sub-unit  $s$ , enrolled in grade  $g$ , in period  $t$ , while  $Minority_{ugt}$  ( $Majority_{ugt}$ ) is the unit level counterpart.

<sup>12</sup> Continental Portugal is administratively divided into 18 districts, each containing several municipalities, see Map A1.

<sup>13</sup> Whereas districts group municipalities, we define five regions grouping contiguous districts in order to simplify the exposition of some results over time. The assignment of districts to regions, although *ad-hoc*, is based on common knowledge regarding their social and demographic similarities (as well as on their geographical proximity). All minority shares (and all segregation measures presented in Section 6) are computed at the school or municipality level, but their estimates' presentation is simplified (using the median) at the district or region level when assessing geographical patterns. Map A1 shows how districts were assigned to the five regions.

<sup>14</sup> These distributions pool only cases of well-defined segregation for each relevant segregation dimension. Section 5 details what we consider a unit-grade-year to be a case of well-defined segregation.

The dissimilarity index is interpreted as the percentage of minority or majority students located in unit  $u$  (municipality or school), enrolled in grade  $g$ , in period  $t$ , who would have to change their current sub-unit (school or class) to achieve a completely even distribution.

As earlier studies point out, e.g. Carrington & Troske (1997) and Allen et al. (2015), the classic dissimilarity index expressed by equation (1) is a measure of segregation in the sense of accounting how unevenly students may be distributed across classes or schools, while not measuring the purposefulness of such distribution as the result of agents' actions. Indeed, Allen et al. (2015) and Carrington & Troske (1997) show that usually some level of distributional unevenness is perfectly coherent with a random allocation process of individuals to sub-units. This is an important observation as we are interested in measuring systematic segregation in the sense of systematic deviations from whatever the level of unevenness that may be aligned with a random allocation process. The actual segregation measure used in this paper follows a recent reformulation proposed by Allen et al. (2015) of the dissimilarity index, which intends to measure systematic segregation more closely related with purposeful actions by the relevant actors (students, families, school authorities), and which is more robust to cases in which certain fundamental parameters approach extreme values that render the problem of segregation not well defined. Before delving into this new index and detailing what we consider to be well-defined cases of segregation, we first summarize the main technical properties offered by the classic dissimilarity index (which its recent robust version inherits) that have been advanced across several studies (e.g. Duncan & Duncan, 1955; Hutchens, 2001; and Allen & Vignoles, 2007; among others as reviewed in Section 2).

The dissimilarity index is 0-1 bounded,  $D_{ugt} \in [0,1]$ , with value zero meaning all sub-units possess exactly the same minority/majority proportions as observed in the whole unit (which can be labeled as the fair shares,  $\frac{Minority_{ugt}}{Minority_{ugt}+Majority_{ugt}}$  and  $\frac{Majority_{ugt}}{Minority_{ugt}+Majority_{ugt}}$ , respectively), hence no segregation, and with value 1 (i.e.  $D_{ugt} = 100\%$ ) reflecting maximum possible segregation, or, equivalently, the need to displace all of the minority (or majority) students from their currently assigned sub-units in order to achieve a perfectly even distribution of both types of students across all sub-units. The index also belongs to a family of indexes known as segregation curve indexes. The segregation curve is analogous to the income/wealth inequality curve. It can be shown that whereas the area between the diagonal (i.e. the segregation curve attained under a perfectly even distribution of minority students across sub-units) and the observed segregation curve is exactly the Gini index, the dissimilarity index simply measures the maximum distance between those two curves (empirically both indexes are usually quite correlated). Finally, the dissimilarity index satisfies a set of desirable principles: (1) *scale/composition invariance* – the index does not vary in the face of a change in the number of minority or majority students, as long as the minority/majority proportions  $p_{sgt}^1$  and  $p_{sgt}^0$  remain unchanged across all  $S_{ugt}$  sub-units; (2) *symmetry in groups* – index does not vary if sub-units are reordered in the formula of equation (1); (3) *principle of transfers* – index does change whenever a minority student is transferred from one sub-unit to another as long as (i) that transfer changes minority proportions in both sub-units, (ii) the two sub-units involved ( $s$  and  $s'$ ) have pre-transfer minority proportions  $\hat{p}_{sgt}^1$  and  $\hat{p}_{s'gt}^1$  below and above the minority fair share; (4) *organizational equivalence* – index does not change if sub-units are



equally and proportionally divided into several sub-sub-units; (5) *symmetry between types* – index does not change if types “minority” and “majority” are swapped in the formula of equation (1).<sup>15</sup>

The segregation measure used in this paper,  $D_{dc,ugt}$ , follows a recent reformulation of the dissimilarity index proposed by Allen et al. (2015) – equation (3.4) in their article – and takes the form

$$D_{dc,ugt} = \frac{1}{2} \sum_{s=1}^{s_{ugt}} \hat{\sigma}_{sgt} n(\hat{\theta}_{sgt}) \quad (2)$$

where the subscript  $dc$  stands for “density-corrected” as proposed in the reference. Moreover, we have

$$\hat{\sigma}_{sgt} = \sqrt{\frac{\hat{p}_{sgt}^1(1 - \hat{p}_{sgt}^1)}{Minority_{ugt}} + \frac{\hat{p}_{sgt}^0(1 - \hat{p}_{sgt}^0)}{Majority_{ugt}}}$$

$$\hat{\theta}_{sgt} = \frac{|\hat{p}_{sgt}^1 - \hat{p}_{sgt}^0|}{\hat{\sigma}_{sgt}}$$

and

$$n(\hat{\theta}_{sgt}) = \begin{cases} 0 & , \quad \hat{\theta}_{sgt} \leq 1 \\ \hat{\theta}_{sgt} & , \quad \hat{\theta}_{sgt} > 1 \end{cases}$$

The density-corrected index is such that a value of zero is assigned to the contribution of sub-unit  $s$  toward the unit level segregation quantity, whenever this sub-unit exhibits a difference (in absolute value) between the proportions of minority and majority students that is less than  $\hat{\sigma}_{sgt}$ . In turn,  $\hat{\sigma}_{sgt}$ , is the estimated standard deviation of the random variable “ $\hat{p}_{sgt}^1 - \hat{p}_{sgt}^0$ ”. Intuitively, this can be seen as canceling the contributions (toward the unit level segregation quantity) of the sub-units whose differences of proportions are relatively small compared to the estimated variability of such differences, or, in other words, not allowing sub-units with relatively too noisy differences of proportions to affect the unit level estimate of segregation. Doing so ensures that the unit level segregation quantity is not driven by potentially large differences of proportions (at the sub-unit level) that could have potentially been much smaller had the sample been slightly different than the one observed.

As noted above, there are two main advantages of measuring segregation via the density-corrected dissimilarity index than via the classic one. On one hand, it measures systematic segregation beyond segregation consistent with random allocation of students to sub-units. On the other hand, it is more robust to cases in which important parameters such as unit level minority share and unit sizes approach certain extreme values that render the problem of segregation not well defined. Nevertheless, even the recently proposed index will exhibit some inflation – a mechanical upward bias of the index as those parameters approach zero (e.g. due to the number of minority students being markedly lower than the number of sub-units to which they are distributed, causing a surge of “spurious” unevenness at the unit level as complete evenness is impossible to achieve) – though less so than the classic index. It is then important to define the parameters’ space in which the measurement of segregation occurs with no or little inflation bias. Figures A6 and A7 (Appendix A) collect all scatterplots of number/share of minority

<sup>15</sup> The square root index (Hutchens, 2001 and Hutchens, 2004) satisfies the same list of principles and even a stronger version of the *principle of transfers* in which requirement (ii) does not have to be imposed. Nevertheless, we still prefer to work with the dissimilarity index as it is a popular measure – and thus easier to compare results.

students against the average segregation measured by both indexes.<sup>16</sup> Clearly, as the number and share of minority students approach zero, both the classic and the density corrected indexes exhibit an upward trend, regardless of segregation dimension or level of analysis. In turn, graphs in the first row of Figure A8 (Appendix A) show the same pattern for average school sizes (averaging across all schools belonging to the same municipality-grade-year), though less pronouncedly. Its second row graphs show that average class size seems to not exhibit extremely inflating behavior, at least excluding non sensical class sizes of fewer than 10 students or more than 30 (which result from a minority of cases with a mismatch between administratively recorded and actual class sizes). Overall, these inflating patterns align with earlier research, e.g. Carrington & Troske (1997) and Allen et al. (2015).

Figures A6-A8 also show that the density-corrected dissimilarity index is, as expected, more conservative in measuring systematic segregation than the classic one. Roughly, the largest “corrections” are brought about when the parameters are close to zero, but not too close.

Across all scatterplots of Figures A6-A8 we also depict thresholds (vertical dashed lines) for each parameter that we consider to delimit the cases in which segregation is well defined. In short, we keep the cases that comply with the following restrictions: (i) units with 10 or more minority students; (ii) units with two or more sub-units; (iii) average school size of at least 30 students for municipality-level analysis, or average class size between 10 and 30 students (including) for school-level analysis; (iv) units with share of minority students between 10 and 90 percent; (v) units with at most 10% of share of students with missing information with respect to the relevant dichotomous variable; and (vi) units with at least 80% of the corresponding sub-units having at most 20% of students with missing information with respect to the relevant dichotomous variable. Tables A3 through A8 (Appendix A) decompose both the original sample and the one complying with all the restrictions just outlined, across the 18 districts of continental Portugal, the 12 grades, and all of the academic years from 2006/07 to 2016/17. They also provide information on how many cases are “lost” due to each of the abovementioned restrictions (i) through (vi). The final restricted sample consists of all cases complying with all six restrictions at the same time. Because there are cases not complying with just one of the restrictions, as well as cases not complying, simultaneously, with two or more restrictions, the final percentage of “surviving” cases does not have to be the product of all shares respecting each restriction alone. However, these shares are still informative regarding which ones are more likely to act as bottlenecks for the final restricted sample.

While not pretending to be exhaustive in the interpretation of all patterns across all these Tables (A3-A8), a few comments are due: (1) the percentage of cases in which we see segregation to be well defined is larger at the school-grade-year level (within-school segregation) than at the municipality-grade-year level (between-school segregation), which seems to be driven by larger shares of school-grade-year cases surviving restrictions (ii) and (iii); (2) the percentage of well-defined cases with respect to economic and academic segregation are higher than the percentages of such cases for the immigrant dimension (this is explained by the clustering of students with immigrant background in the densest urban areas of Lisboa, Setúbal, and Faro – in line with the findings of Justino et al. (2017) – rendering schools or municipalities outside those areas less likely to comply with restrictions (i) and (iv) for that

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<sup>16</sup> These scatterplots were produced using the Stata command *binscatter*, using the *discrete* option, see Stepner (2013). Dots of the same color almost always represent *different* amounts of observations, i.e. they represent only those unit-grade-years with the exact same value in the horizontal axis. The averages of  $D$  or  $D_{dc}$  are then taken across all unit-grade-years sharing the same horizontal axis value.

dimension in particular)<sup>17</sup>; (3) the percentages of well-defined cases with respect to economic and academic segregation seem to be higher across schools and municipalities located in more densely populated districts such as Lisboa, Porto, Setúbal, and Faro; while some northern, less urbanized, districts such as Vila Real, Viana do Castelo, and Viseu have relatively large shares of surviving school-grade-year cases of well-defined within-school economic segregation in particular (Figure A3 shows that these are some of the districts with the largest median shares of low-income students in the country, and are therefore more likely to comply with restrictions (i) and (iv)); and (4) there are none to very few well defined cases of academic segregation in grades 1 and 2 at the municipality level (retentions are not practiced on 1<sup>st</sup> graders, and by grade 2 the share of students with at least one retention is still not as large as in subsequent grades); and, at the school level, no segregation dimension was considered for the whole arc of primary schooling grades – 1 through 4 – given the relatively high incidence of mixed-grade classes.<sup>18</sup>

To sum up, our choice of  $D_{dc}$  over  $D$  is based on the combination of several reasons: (1) it is an improvement on the popular dissimilarity index, meaning that there exist several instances to compare our results with, and, conversely, it is more likely for others to be able to compare their findings with those from the Portuguese case that we bring here; (2) it inherits from the classic dissimilarity index the same interpretation and other useful properties (e.g. 0-1 bounded; not dependent on minority share, hence comparable across units and time; only requires dichotomous students' characteristics); and (3) it captures systematic segregation in a more robust way, exhibiting less bias under small values of minority share and of unit sizes than  $D$ . In turn, our preference for the density-corrected dissimilarity index over the other indexes proposed in Allen et al. (2015) (and over others such as Carrington & Troske, 1997) is grounded on two factors: (1) it is the most suited for our very large dataset encompassing millions of student-level observations as it does not require extensive reassignment procedures (of all individual students to actual schools or classes) in the spirit of bootstrapping as the alternatives do, and (2) it is shown in Allen et al. (2015), through Monte Carlo simulations, to actually be *more* bias-correcting than the alternatives.

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<sup>17</sup> The second most urbanized area of Portugal – Porto – is clearly the exception, because the number of foreign students living there is small compared with its total student population (although the number of foreign students living there is quite sizeable compared to the total number of foreign students of the country). Moreover, it is important to mention that we have found, in ongoing parallel research devoted to analyzing the types of immigrant students found in different areas of the country, that they can be grouped into two main types. One has to do with students whose cultural background is Brazilian, African (Portuguese speaking countries), or Eastern European. The other has to do with students born in countries that are usually targets of Portuguese emigration (e.g. France and Switzerland) having both parents born in Portugal, or, if born in Portugal possessing one parent also born in Portugal and the other born in one of these Portuguese emigration countries. The first group clusters, to a great deal, in the districts of Lisboa, Setúbal, and Faro, whereas the second in center and northern districts.

<sup>18</sup> Mixed-grade classes complicate the interpretation of the segregation index at the school level. The interpretation of the school level index presumes that one may change the allocation of students across classes freely. In cases of single grade classes, the only evident restriction is to allow such allocative changes to happen only across classes of the same grade (and school). However, this becomes blurrier when classes include students of more than one grade. Possible solutions would be to allow students of a given grade to move to any class containing at least one other student from that grade, or to allow such movements only across classes whose majority of students happen to be of that same grade. Nevertheless, these options either allow moving students of a given grade to classes unlikely to be able to receive them (those classes where the students of that grade are a clear minority), or “forget” some of the students (those that happen to be the minority in classes of other grades). Other ongoing research – Araújo, Costa, Crato, D’Hombres et al. (2019) – documents, also using the *MISI* dataset for school-years 2006/07 through 2015/16, that roughly between 20% to 30% of 1<sup>st</sup> cycle students stayed at least one school-year in one mixed-grade class, and about the same values apply for the percentage of 1<sup>st</sup> cycle classes containing more than one grade.

## 6 Segregation Estimates

In this Section we present the estimates of each of the six segregation cases we are interested in – economic, academic, and immigrant segregation dimensions at between and within-school levels. The estimates are presented in Figures 1 and 2 below which decompose them across time and grades, respectively.<sup>19</sup> These estimates refer to percentiles 25 (light grey), 50 (median; dark grey), and 75 (black) of segregation, as measured by the density-corrected dissimilarity index ( $D_{dc}$ ), in which the percentiles are taken from the distribution (of segregation estimates) obtained by pooling all unit-grade-years that (i) are cases of well-defined segregation, and (ii) share the same horizontal axis category. Recall that “unit” is municipality for between-school segregation measures (first row plots), whereas it is school for within-school ones (second row plots). The horizontal dashed series represent percentiles 25, 50, and 75 (of segregation estimates) taken from pooling all unit-grade-years that are just cases of well-defined segregation, and are therefore constant across horizontal axis categories. Every percentile possesses 95% confidence intervals.

The first main insight is the time invariance of median segregation (P50), across all six cases shown in Figure 1, for the decade 2006/07 – 2016/17. The evolution of median segregation seems to exhibit only very faint and linear trends for the cases of academic and immigrant within-school segregation: positive and negative, respectively.

The main exception is the drop of median between-school economic segregation from 2007/08 to 2008/09. Recall from Section 3 that from 2008/09 on the procedure to attribute socioeconomic support to families changed, with this change allowing families with somewhat higher income levels to gain access to levels of support for which they were earlier not eligible. At the end of Section 4 we noted that the increase in this minority share varied, roughly, from 5 to 10 p.p. depending on cycle of studies. This means that several students defined as low-income from 2008/09 on would not be defined as such had they been subject to the previous rules. The drop should, then, reflect a break in the series rather than a structural change in economic segregation, motivated by at least two factors. First, previous to the reform, the fewer (flagged as) low-income students were more likely to be found only in specific schools of the municipality due to the combination of residential segregation and school catchment areas. The reform is likely to have increased the probability of finding the “new” low-income students more scattered across the schools of any given municipality, thereby contributing to the drop of this type of segregation. Second, as the attribution of free school meal status ceased to be decided at the school level (it passed to the central government level) it may also be the case that school level tradition, culture, or simply technical capacity ascertaining whether a given student truly belonged to a low-income household or not, ceased to be another source of between-school economic segregation. With central government determining which students belong to a low-income household or not, the attribution of this status across students (of different schools of the same municipality) may have been homogenized. This may have decreased between-school economic segregation because the likelihood for students from different schools to obtain that status simply became more balanced.

It is also noticeable the absence of visible patterns for both between and within-school economic segregation during the severe economic crisis that began around 2010 and had its apogee during the external economic

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<sup>19</sup> Figure B1 of Appendix B shows the segregation estimates across districts of continental Portugal. Appendix B contains all Figures and discussion related to regional differences of the segregation estimates.

intervention between mid-2011 and mid-2014. It seems that the economic crisis had no impact on student economic segregation.

The final insight we take from Figure 1 is the fact that throughout the period considered, median within-school academic segregation was greater than the other two remaining segregation dimensions. Compared to these other two dimensions, which recorded median segregation levels of around 15%, the former recorded a higher median index by around 10 p.p., i.e. around 25%. This fact gains importance taking into consideration that Portugal is one of the OECD countries with the highest retention rate (see Figure 1 of Ikeda & García, 2014). It shows that within-school academic segregation affects a substantial portion of Portuguese students (especially as they progress in grade, see our Figure A2). The same qualitative difference (greater academic than economic segregation) is observed at between-school level (not within-school as herein) in Figure 3.1 of OECD (2019) for Portugal, though there are some important differences in the way we and OECD (2019) define low-income students and pupils with a low academic record.<sup>20</sup> Moreover, they use the classic dissimilarity index, not the density-corrected one, and compute between-school segregation at the country level, not at the municipal level, as we do.

In contrast to the school-years profile the grade-segregation profile (Figure 2) is richer in observable patterns. Looking at between-school segregation (first row graphs) one notices that across all three dimensions the highest median segregation levels are attained during cycle 1 (grades 1 to 4), at around 17% to 19%. It then falls to around 12% to 14%, depending on dimension, during cycle 2 (grades 5 and 6). Throughout cycle 3 (grades 7 to 9) it either increases a bit to around 15% (economic and academic dimensions) or stays around the previous cycle level (immigrant dimension). During cycle 4, (grades 10 to 12), median segregation levels decrease again, namely those related to economic and immigrant dimensions.

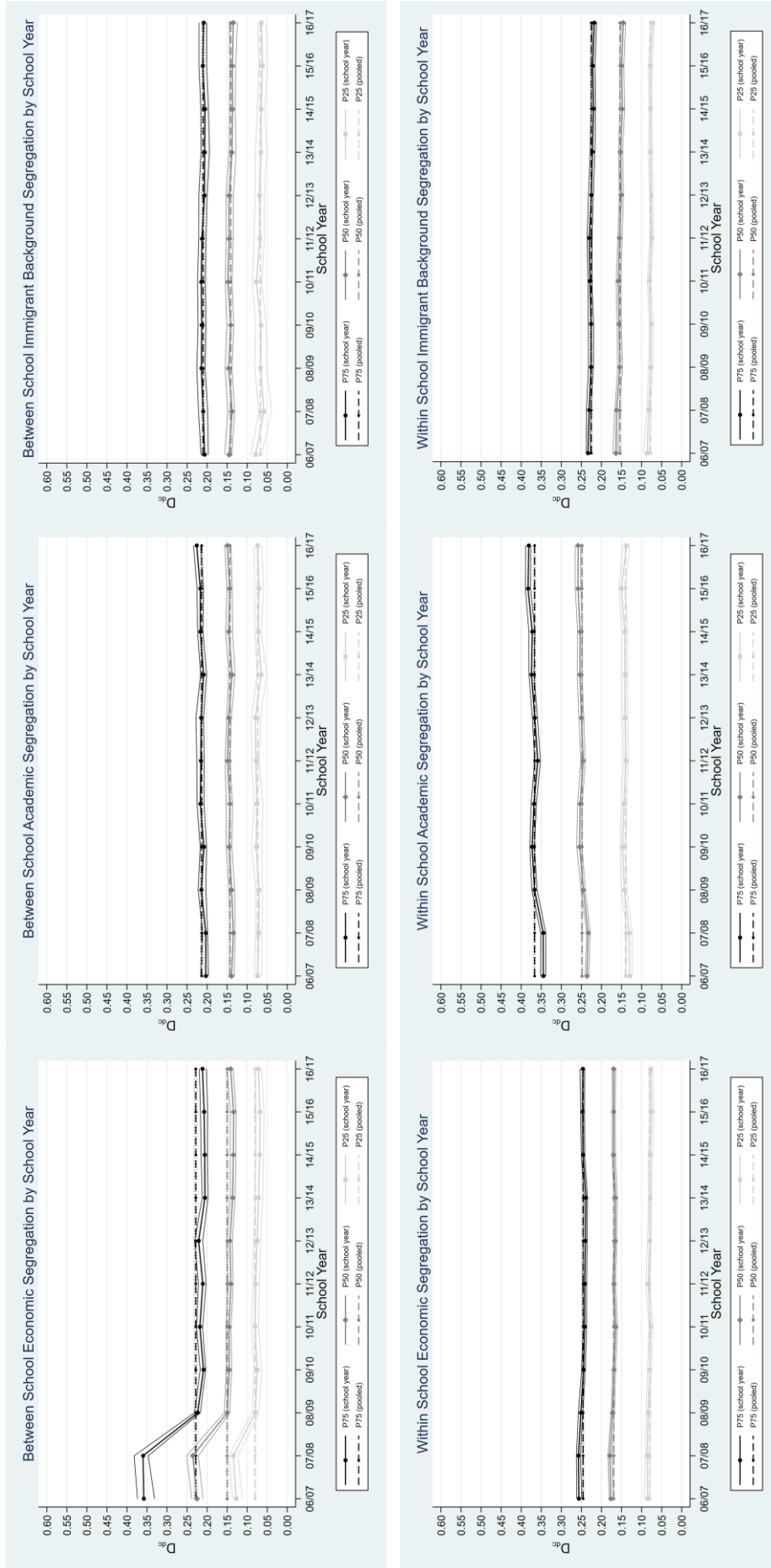
We view these patterns (constant within but varying across cycles of studies) reflecting, at least to some degree, latent residential segregation through the varying granularity of the networks of schools that offer each cycle (see Table A1). Primary schools, which offer cycle 1, are the most frequent and widespread schools in the country. The top row graphs of Figure A9 (Appendix A) show that the median number of schools, for each sample of well-defined cases of segregation, is largest during grades 1 to 4: around 7 to 10 schools in a given municipality-grade-year. This, combined with the fact that between-school allocation of students is influenced by school catchment areas and students' residency, may explain why primary schools seem to receive minority and majority types of students in a relatively more unbalanced way. In short, these schools should attract students from more local and homogeneous neighborhoods (within a given municipality), so it would be necessary to reallocate a higher proportion of minority (or majority) students across the municipality's primary schools to achieve a completely even minority/majority distribution.

This same argument may be applied to the lower between-school segregation levels observed during cycle 2. The network of schools offering cycle 2 grades (which, for certain, also offer cycle 3) is less widespread than that constituted by primary schools (top row of Figure A9 reports a median of about 3 schools per municipality-grade-year supplying that cycle, which corresponds to approximately a third that of primary schools). It is then expectable, and supported by what is shown in Figure 2, that cycle 2 schools attract students less locally and with a more diversified background than the latter schools do.

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<sup>20</sup> We do not possess a socioeconomic index like the ESCS, just information on free school meal take up; and we do not take into account test scores (OECD, 2019 uses reading PISA scores).

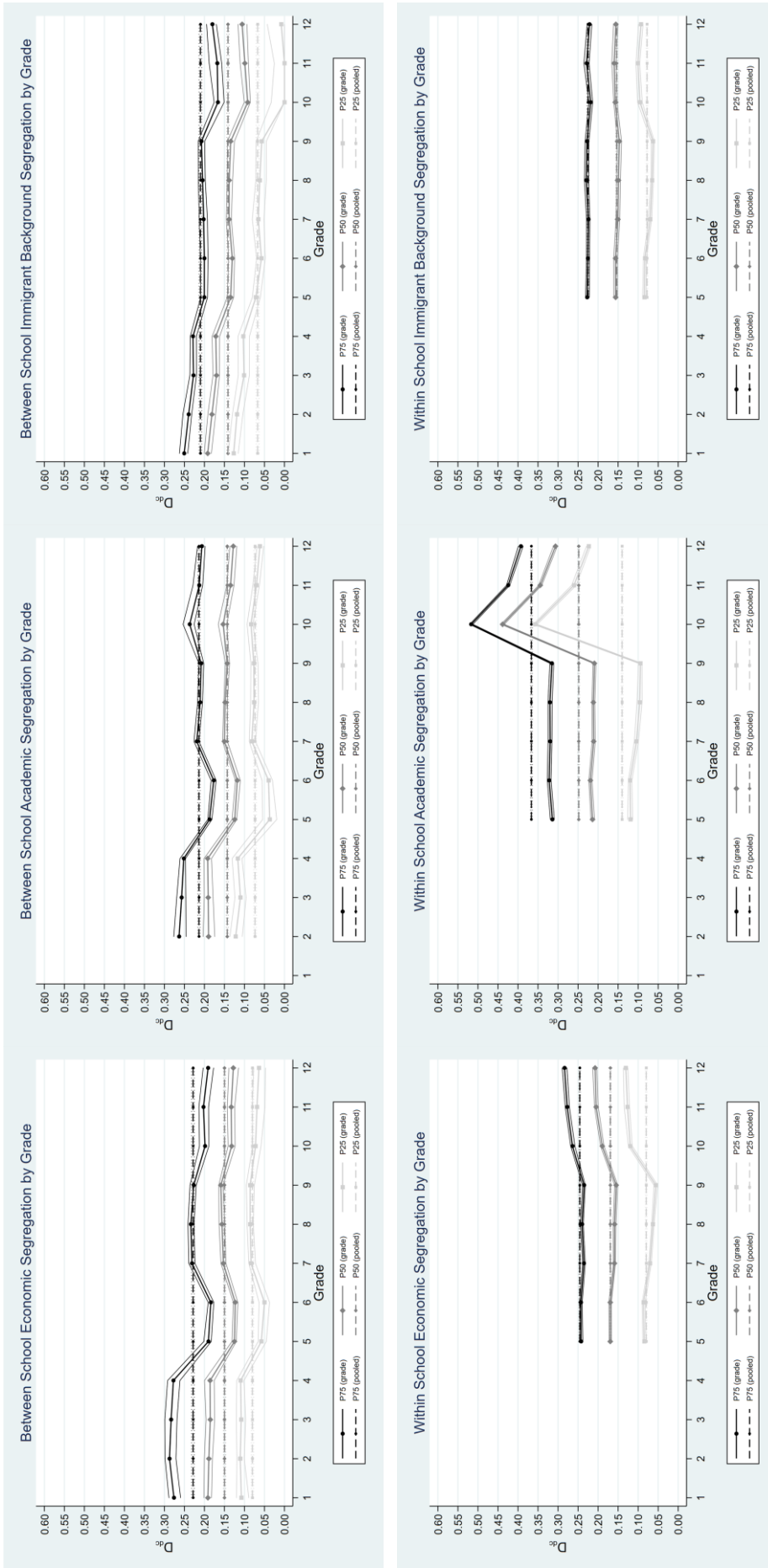
Figure 1 – Segregation Over Time



Notes: All series represent estimates of segregation as measured by the density corrected dissimilarity index ( $D_{dc}$ ). P25, P50, and P75 (connected lines) correspond to percentiles 25, 50 (median), and 75, respectively, from the distribution obtained by pooling all unit-grade-years that (i) are cases of well-defined segregation\*, and that (ii) share the same horizontal axis category. “Unit” is municipality for between-school segregation measures (first row plots), and school for within-school ones (second row plots). P25, P50, and P75 (dashed lines) represent percentiles 25, 50 (median), and 75 taken from the overall pool of unit-grade-years that are cases of well-defined segregation, hence constant across horizontal axis categories. All point estimates have 95% confidence intervals.

\*As explained in the text, for within-school measures we only consider the school-grade-year cases whose grade is different from primary schooling (i.e. different from grades 1 through 4), so only those cases are pooled either overall or for each horizontal axis category. The particular plot of between-school academic segregation does not consider municipality-1-year cases, that is 1<sup>st</sup> grade cases, as there are no retentions during this grade (thus percentiles stem from distributions pooling all cases except these).

Figure 2 – Segregation Across Grades



Notes: All series represent estimates of segregation as measured by the density corrected dissimilarity index ( $D_{dc}$ ). P25, P50, and P75 (connected lines) correspond to percentiles 25, 50 (median), and 75, respectively, from the distribution obtained by pooling all unit-grade-years that (i) are cases of well-defined segregation\*, and that (ii) share the same horizontal axis category. "Unit" is municipality for between-school segregation measures (first row plots), and school for within-school ones (second row plots). P25, P50, and P75 (dashed lines) represent percentiles 25, 50 (median), and 75 taken from the overall pool of unit-grade-years that are cases of well-defined segregation, hence constant across horizontal axis categories. All point estimates have 95% confidence intervals.

\*As explained in the text, for within-school measures we only consider the school-grade-year cases whose grade is different from primary schooling (i.e. different from grades 1 through 4), so only those cases are pooled either overall or for each horizontal axis category. The particular plot of between-school academic segregation does not consider municipality-1-year cases, that is 1<sup>st</sup> grade cases, as there are no retentions during this grade (thus percentiles stem from distributions pooling all cases except these).

Grades 7 to 9 – cycle 3 – report, in general, higher median between-school segregation levels than those reported throughout the grades of the cycles immediately before and after them. Again, a good candidate explanation is the (higher) granularity of the network of schools offering grades 7 to 9 as compared to those of schools offering cycles 2 and 4. In fact, in any given municipality, grades 7 to 9 are always offered in schools with grades 5 and 6, and possibly so in schools offering grades 10 to 12. Consequently, the number of schools offering cycle 3 grades can only be equal to or greater than the number of schools offering cycle 2. In practice, the inequality holds more frequently. Figure A9 shows that, indeed, there are, on median, four schools housing 3<sup>rd</sup> cycle students (greater than three, the equivalent figure for cycle 2 students).

In turn, in any given municipality, in general, the number of schools offering grades 7 to 9 is also greater than those offering grades 10 to 12. The latter schools form the least granular network within the public system as they offer the last cycle, the one least populated (2 to 3 schools, on median, per municipality-grade-year, according to Figure A9, depending on which sample we look at).<sup>21</sup> Consequently, upper-secondary schools, again, should attract more heterogeneous students from wider areas, and indeed they seem to do so, as shown by the somewhat lower median between-school segregation levels reported in Figure 2 for grades 10 through 12.

To conclude this particular discussion regarding the profile of between-school segregation and grades, we note that although all three dimensions of between-school segregation seem well described by the previous discussion, there are two peculiarities. First, median between-school segregation related to the immigrant dimension, across grades 7 to 9, is in line with that of the previous cycle (we would expect it to increase, as in the other two dimensions). Second, median between-school academic segregation seems to increase from grade 9 to 10 (the increase is more pronounced for percentile 75), to then attain a slight decrease by grade 12 (we would expect a visible decrease throughout the entire upper-secondary).

Whereas the interpretation of the first case remains unclear to us, we interpret the second case as having to do with the choice students are required to make in terms of which course to enroll in at the beginning of grade 10 (as pointed out in Section 3). It is known that many schools offering upper-secondary grades (10 to 12) offer fewer regular courses than possible, in any given school-year. This makes the course choice also a school choice whenever, within any given municipality, not all upper-secondary schools offer the same set of courses. It is conceivable that students with different academic abilities (as roughly flagged by having at least one retention by the beginning of grade 10) tend to enroll in regular courses differing in academic difficulty (e.g. there is the view that the exact sciences course may be more academically demanding given the more complex mathematics involved in it, as compared, for example, with the humanities course, which makes students go through less demanding mathematical contents). Such a mechanism would translate into students of similar academic ability clustering in specific upper-secondary schools within the municipality, thereby sourcing upward pressure on academic segregation. In turn, this upward pressure is likely to balance the negative one from a less granular network of schools, thus explaining the particular peculiarity that between-school academic segregation does not decrease from cycle 3 to 4 (not as much as it does with respect to the economic and immigrant dimensions).

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<sup>21</sup> Some students leave the upper-secondary when turning 18 years-old. On top of this, there are other tracks available at the end of 9<sup>th</sup> grade, namely vocational and professional tracks, which absorb another non-marginal portion of individuals (see Table A2).



Within-school segregation presents two distinct profiles with respect to school grades (second row of Figure 2). The first is a constant level of median segregation during cycles 2 and 3 (grades 5 through 9). It is around 15% to 17% for economic and immigrant dimensions, and around 21% for the academic one. These are the cycles through which regular track students have no choices to make regarding courses or classes. Because of this fact we view these segregation levels as reflecting, mostly, choices of school authorities (parents may also have some impact on within-school placements through informal bargaining, although the final responsibility on actual classes' composition resides entirely with the school authorities). Recall that schools are mandated to compose classes reflecting the school-grade-year specific student heterogeneity. Perfect compliance with that rule would mean null within-school segregation levels because all classes would record the fair shares of minority/majority students, i.e. each class would absorb balanced proportions of each type of student from the school-grade-year observed pool. The empirical evidence just presented suggests that, on median, that mandate is not perfectly complied with, at least during cycles 2 and 3. This is consistent with the fact that schools are not provided with exact quantitative bounds on what it means to comply with the school-grade-year observed heterogeneity, thus leaving room for schools to deviate from null segregation. On the other hand, the empirical results also reveal that the magnitude of the deviation is, at best, mild, on median, taking into account that the observed levels of within-school segregation could theoretically be as high as 100%.

The second distinct profile with respect to school grades has to do with the upper-secondary (grades 10 to 12). Given that upper-secondary classes tend to group students that opted for the same upper-secondary course, the students' choices may result in student-induced within-school segregation. This is so because students with similar academic aptitudes tend to take the same courses<sup>22</sup> and, indirectly, make themselves be found in the same upper-secondary school classes. This seems to match the empirical estimates observed in the second row of Figure 2, namely those related to the economic and academic dimensions. Between these two cases it is that of academic within-school segregation that strikes the most. Whereas throughout grades 5 to 9 the median revolves around 21%, it jumps by almost 25 p.p. to about 45% by grade 10. In other words, it would be necessary, on median, in any given upper-secondary school, to redistribute almost half of the 10<sup>th</sup> graders recording at least one retention, across the existing classes, in order to achieve a completely even distribution. Grades 11 and 12 then show a progressive decrease to 30%, which is still about 10 p.p. higher than the median levels observed until 9<sup>th</sup> grade.

This result is somewhat at odds with that from Holfve-Sabel (2015), who found that students may counteract within-school (immigrant) segregation via their inclusive decisions about whom to work with during lessons. Nevertheless, such apparent discord might be explained by at least two factors: (1) the fact that Holfve-Sabel's study deals with 6<sup>th</sup> graders while our result arises from decisions of older students (9<sup>th</sup> to 10<sup>th</sup> graders), who may possess different inclusiveness preferences, or (2) with the idea that despite pursuing immigrant background inclusiveness, students may not pursue inclusiveness in terms of academic ability, especially when it comes to such a long-lasting decision as the choice of an academic track (which clearly contrasts with the short-lived decision of whom to work with during lessons).

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<sup>22</sup> This academic ability concentration also seems to be the case for the French school system. As described by Rapoport & Thibout (2018), almost all students found in the most demanding French universities attended the same secondary sciences course and, likewise, secondary students graduating from this course are the most able to pursue any course at university level.

The case of within-school economic segregation is less striking, but it also presents an increase of median segregation of about 5 p.p. (from 15% to 20%) between grades 9 and 12. Median immigrant within-school segregation does not vary much across grades. Overall, academic characteristics of the students seem to play an important role in how they end up distributed across classes of any given school, and a very important one across classes of upper-secondary schools. Meanwhile, economic and immigrant statuses seem to play less important roles, though still non-null ones.

We also analyzed all six segregation cases by cycle of studies over time (Figures A10 and A11 in Appendix A).<sup>23</sup> Aside from showing that the series break of between-school economic segregation was felt more heavily for cycle 1 students (and much less for those in cycle 4), Figure A10 does not show major changes over time of median segregation levels by cycle. Bêa (2018) also detected a very similar profile for between-school economic segregation from 2006/07 to 2015/16, for cycle 1 students in the municipality of Lisboa, as the one presented in Figure A10 (which takes into account not only that municipality, but all other municipalities of the country for which between-school economic segregation is well-defined). Although Bêa's (2018) estimates for this type of segregation are larger than ours for every comparable school-year by a mark-up of 20-35 p.p. (she uses the classic dissimilarity index, which yields larger estimates than its density-corrected version and looks only at Lisboa municipality, which also tends to exhibit higher between-school segregation than the country), we agree on the size of the fall from 2007/08 to 2008/09: she estimates a drop of about 21 p.p. whereas we calculate it to be around 17 p.p., for 1<sup>st</sup> cycle students. In turn, the estimates of between-school immigrant segregation in Bêa (2018) show a constant profile over time, just as our estimates do, but with a mark-up relative to ours of about 20 p.p..

Allen et al. (2015) report levels, also on between-school economic segregation for cycle 1 schools (2006 data), ranging between 16% and 30% across inner London local authorities with the density-corrected dissimilarity index. The Portuguese case, for the comparable segregation dimension and cycle, seems, on median, to fall within the lower half of that band since at least 2008/09.<sup>24</sup> Moreover, the Portuguese between-school economic segregation levels may also be aligned with those from Rio de Janeiro Municipal Schools. According to Bartholo (2013) the between-school economic segregation levels there, applying the classic dissimilarity index on students from grades 1 through 9, are close to 25%. This level of segregation may diminish to values closer to what we obtain here under the density-corrected dissimilarity index for each comparable cycle. In turn, comparing our results to those from Murillo & Martínez-Garrido (2018) that estimate between-school economic segregation for European countries (including Portugal), with PISA 2015 data, using the *G* index, we note that whereas their estimate for Portugal is 36% (38% for Spain), which would translate in terms of *D* to around 40% to 50%<sup>25</sup>, our most comparable estimate (mid-left graph of Figure A10, cycle 3 series, academic years 2014/15 and 2015/16) is below 15%, a much lower level (though at municipality level, not at the country level as in the reference). Furthermore, Figure A10 confirms that, in general, between-school segregation tended to be higher for cycle 1 students, and lower for cycle 4. This is reversed regarding

<sup>23</sup> Figures A10, A11, B2, and B3 in Appendices A and B are graphically heavy as they portray, for the sake of completeness, all combinations of levels of analysis (2), with segregation dimensions (3), with percentiles (3), by cycles and regions (2), thus totalling 36 different graphs. To keep the discussion in the text succinct we restrict the subsequent analysis to the patterns of the medians only (middle row graphs of each Figure).

<sup>24</sup> Municipalities, though, are likely to be larger regions than inner London LAs, so comparability may not be exact.

<sup>25</sup> Applying the formula of footnote 3 and taking 24% as the share of low-income students, as per top-left graph of Figure A4, cycle 3 series, academic years 2014/15 and 2015/16.

within-school segregation (Figure A11), since economic and (especially) academic unevenness levels for cycle 4 were the largest throughout the whole period.

We can further relate, in at least three ways, our findings with respect to between and within-school immigrant segregation with those documented in Conger (2005), who analyzed these two phenomena across and within public elementary schools of the New York City (NYC) school district, between 1995/96 and 2000/01. First, in the NYC case immigrant students enrolled in grade 5 tended to be more segregated both between and within-schools than their grade 1 counterparts. We observe the reverse. Figure A10 shows 1<sup>st</sup> cycle students (grades 1 through 4) subject to median between-school immigrant segregation significantly higher, not lower, than that for 2<sup>nd</sup> cycle pupils (grades 5 and 6), over almost all school-years (we cannot compare with the within-school estimates shown in Figure A11 since, as explained above, we do not compute that level of segregation for 1<sup>st</sup> cycle students). Second, being able to compare immigrant and racial segregation levels across and within the same schools, Conger (2005) observes that “total” immigrant segregation is lower than “total” racial segregation.<sup>26</sup> A crude extrapolation to the Portuguese case of this finding would suggest that the estimates here provided, relative to median immigrant segregation, are possibly lower bounds of actual median racial/ethnic segregation levels. Evidently, lacking information on the actual racial/ethnic category of the students, we cannot confirm or rule-out this hypothesis. Nevertheless, we believe it would be important to test it in the future, given the likely racial/ethnic diversity of the Portuguese student population (see Hortas, 2013, Abrantes et al., 2016, and Araújo, 2016). Lastly, our estimates agree with those of Conger (2005) qualitatively, as both studies conclude that between and within-school immigrant segregation levels have equal magnitudes (15% in our case).

Regarding percentiles 25 and 75 of all six cases of segregation presented there are no significant qualitative differences to add to the above discussion based on the median. These other two percentiles follow, in general, the same patterns of the latter. However, these two percentiles convey interesting information related to the degree of dispersion of the unit-grade-year segregation distributions. In general, the interquartile range (the vertical distance between P75 and P25) of all series presented in Figures 1 and 2 revolve around 15 p.p., which indicates that in any given school-year, grade, or district, there is some heterogeneity in segregation estimates, implying heterogeneity in the way agents such as parents and school authorities contribute to observed segregation patterns. The case of within-school academic segregation, however, should again be highlighted since it presents the largest interquartile range: around 20 to 25 p.p.. In other words, within a given school-year or grade, there are greater discrepancies in the way different schools’ authorities set up classes in terms of their composition with respect to students’ academic characteristics than in terms of their economic or immigrant composition. For example, looking at Figure 2 middle bottom graph, one can see that a quarter of schools containing 9<sup>th</sup> graders imposed on their students a level of academic segregation of less than 10%, whereas another quarter of such schools imposed a level of academic segregation of more than 33%.

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<sup>26</sup> “Total” refers to the sum of between and within-school segregation components. The racial categories considered were: White, Black, Asian, and Hispanic.

## 6.1 Correlations

So far we have described the profiles of the three segregation dimensions – economic, academic, and immigrant – in terms of time and grades (and districts in Appendix B). In this subsection we look at whether there are systematic associations between the most important variables at the root of the segregation phenomena, i.e. between all possible pairs of variables of minority shares and dimensions of segregation. We define an association to be systematic whenever there is a significant correlation between the pair of variables being compared, *after* partialling out, from both of them, municipality (or school whenever appropriate), grade, and year fixed effects, and holding fixed all other minority shares or segregation dimensions not belonging to the pair analyzed. Such a correlation coefficient tells us the level of association between the considered pair of variables that exists *independently* from statistical units, grades, and years' specific factors (such as municipality/school specific time-invariant tendency to cluster specific types of students or to segregate in any particular way, or grades' tendency to contain specific students or to be associated with specific geographic granularities of schools, or specific school-years' regulations and policy regimes), as well as from confounding associations between minority shares and segregation dimensions outside the pair of variables analyzed.

Table 2 shows the (partialled-out) correlation estimates (those larger than 0.2 in absolute value are bolded to highlight cases with no economically significant correlations from significant ones). Each estimate within the matrix was obtained in a two-stage procedure: first, municipality (or school), grade, and year fixed effects were partialled-out from each municipality (or school) level variable present in the matrix; second, a partial correlation matrix was computed using the residuals of the regressions from the previous stage.<sup>27</sup>

Looking first at the blocks of correlations related only with minority shares, we observe that (1) there are no visible correlations between minority shares at the municipality level (not larger than 0.2 in absolute value), (2) at the school level the share of students with at least one retention correlates positively with the share of low-income students (and seems to correlate also positively with the share of students with immigrant background, although weakly), and (3) the strongest correlations are reported at the intersection of the municipality and school levels, namely in that block main diagonal. These latter correlations mean the larger the minority shares at, say, municipal level, the larger the *same* minority shares at the schools of that municipality (the correlations are far from unity though, suggesting that variations in minority shares at one level are not 1-to-1 matched by equivalent variations on the other level; this is coherent with the students' between-school allocation process as it must respect, to some extent, proximity to school, though not exactly, as students may enroll in schools located in a different municipality compared to that of their residence through the location of the parents' jobs).

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<sup>27</sup> The sample consists of school-grade-years that are, simultaneously (i) well-defined cases of segregation across all three segregation dimensions, and (ii) matched to the appropriate municipality-grade-years, which, in turn, also are well-defined cases of segregation across the same three dimensions.

Table 2 – Segregation and Minority Proportion Correlation Matrix

Residual Partial Correlations (N = 17,248)		Municipality						School					
		Segregation			Population Share			Segregation			Population Share		
		Immig. Back.	Economic	Academic	Immig. Back.	Low Income	1 Retention	Immig. Back.	Economic	Academic	Immig. Back.	Low Income	1 Retention
Municipality	Immig. Back.	1											
	Economic	0.05*	1										
	Academic	0.16*	<b>0.23*</b>	1									
	Immig. Back.	-0.13*	0.06*	0.04*	1								
	Low Income	-0.04*	<b>-0.23*</b>	0.01	0.07*	1							
	1 Retention	-0.01	-0.01	0.02*	0.12*	0.13*	1						
School	Immig. Back.	0.02	0.00	0.00	-0.03*	0.00	-0.01	1					
	Economic	-0.02	0.01	-0.01	0.00	0.01	0.00	0.05*	1				
	Academic	-0.01	0.01	0.02*	0.00	0.01	0.03*	0.05*	<b>0.20*</b>	1			
	Immig. Back.	0.13*	-0.03*	-0.02*	<b>0.39*</b>	-0.02	-0.08*	-0.06*	0.00	-0.01	1		
	Low Income	-0.03*	0.11*	0.01	-0.06*	<b>0.35*</b>	-0.05*	0.03*	-0.06*	0.03*	0.10*	1	
	1 Retention	-0.04*	-0.01	0.03*	-0.06*	-0.10*	<b>0.30*</b>	0.01	-0.01	0.09*	0.18*	<b>0.32*</b>	1

Notes: This correlation matrix is the result of a two-stage procedure. In the first stage municipality (school), school-year, and grade fixed effects were partialled-out from each municipality (school) level variable present in the matrix. In the second stage a partial correlation matrix was computed using the residuals from the first stage. In this way, the partial correlations shown here report the level of (linear) association between any pair of variables beyond the confounding influences of municipality (school), school-year, and grade specificities, as well as, holding fixed all the other variables present in the matrix. Partial correlations greater than or equal to 0.2 (in absolute value) are statistically significant, and those with \* are statistically significant at 5% level.

Next, potential strong correlations in blocks that intersect minority shares and segregation levels could indicate that different compositions of student populations are systematically associated with different segregation patterns. There is one such case: the share of low-income students at the municipal level and between-school economic segregation, with an estimated and statistically significant correlation of -0.23. This figure implies that municipalities with larger shares of low-income students tend to exhibit lower levels of segregation of this type of student between their schools, though the relationship is not perfect. This particular result should not be an artifact of the measure of segregation chosen, as the dissimilarity index (and the density-corrected one) does not depend on the shares of minority/majority at the unit level, nor on ill-defined cases of segregation, as these were dropped from the analysis, nor even on the change of the rules to gain free school meal status (which herein identifies low-income students) as the year fixed effects ensure all year-specific factors (such as, precisely, year specific legislation) are not allowed to confound the estimates present in the matrix. Interestingly, the same relationship at the within-school level is almost nonexistent, with a correlation of just -0.06. It seems that it is “easier” to find an increasing proportion of low-income students, of a given municipality, spread out across its schools, than it is to find an increasing proportion of low-income students, of a given school, spread out across its classes.

Last, visible correlations in blocks that are intersections of different segregation measures provide information whether municipalities or schools that tend to separate/pull together students with a given characteristic do it in tandem or not with the way they allocate students with other characteristics. It is possible to observe from the matrix that one such relationship holds at both between and within-school levels: municipalities or schools where low-income students are more segregated tend to be places where students with at least one retention are more segregated, too (correlations of 0.23 and 0.20, respectively, both statistically significant). A possible reason for this might be that low-income students tend to also be students with at least one retention. This is partly supported by the correlations between the shares of these two types of students: 0.13 (municipality level), and 0.32 (school level). Nevertheless, the small minority shares’ correlations leave room for other explanatory factors. Interestingly, the same relationship arises at the country level analysis of 15-year-old students’ between-school segregation by OECD (2019). Our correlations’ results, which explicitly control for a myriad of confounding factors (such as the grade, facilitating the comparison of our correlation results with those from OECD), not only confirm this, but also extend this fact to hold for the Portuguese municipalities and public schools.

A possible criticism regarding the values presented in Table 2 is that they depend on a small fraction of the original population of school-grade-year cases (17,248 out of 68,605). This is induced by requiring that only school-grade-year cases that are well-defined cases of segregation across all three dimensions simultaneously, and appropriately matched to the respective municipality-grade-year cases (well-defined cases of segregation themselves too), be used. A particular dimension that acts as bottleneck for well-defined segregation is the one related to immigrants. For this reason, we re-estimate the same partial correlations matrix disregarding the between and within-school immigrant segregation measures and associated minority shares. This new matrix is reported in Table A9 (Appendix A). It allows us to use more cases ( $N=26,503$ ), which should be more representative of the entire country (recall that immigration was well-defined mostly only in Lisboa, Setúbal, and Faro districts). There are, however, no substantial changes in the estimates (signs, magnitudes, and precision levels). We thus keep the interpretation of the results found in Table 2.

## 7 Concluding Remarks

In this study we have documented the most comprehensive description to date of the state of student segregation in Portugal, both between and within-schools. While we found that median segregation, at both levels of analysis, is not null, it may be categorized as being mild. Broadly speaking, it varied around 15% to 20% (percentage of minority students necessary to reallocate to achieve evenness) depending on minority dimension and on level of analysis. There are, however, specific cases in which segregation is more intense and other interesting patterns arise.

Within-school academic segregation shows the highest levels. Given that within-school economic and immigrant segregation lag behind academic segregation we interpret this as evidence that academic characteristics of the students are somewhat more prioritized at the moment of forming classes, over their socioeconomic characteristics. This view, however, should be conditioned to grades 5 through 9, when students do not have to self-select to specific courses. When they are asked to do so, by grade 10, within-school academic segregation increases sharply, reflecting the addition, above a “natural” segregation level imposed by school authorities, of segregation stemming from students’ own tracking decisions. In addition, within-school academic segregation also presents greater interquartile ranges, implying that within a given school-year or grade there are greater discrepancies in the way different schools’ authorities set up classes in terms of their academic composition than in terms of their economic or immigrant composition. These within-school segregation patterns may very well be impacting students’ educational and non-educational outcomes, in light of the literature on peer effects (e.g. Burke & Sass, 2013).

Between-school segregation varies somewhat *across* primary, upper-primary, lower-secondary, and upper-secondary, but much less across grades *within* each of these cycles. We believe this may be explained by the combination of two factors. First, different types of schools, supplying specific grades, possess varying geographical granularities. Municipalities with more schools are likely to exacerbate pre-existing residential segregation patterns. Second, the existence of school catchment areas reinforces the effect of the previous factor. It seems to force students with similar socioeconomic characteristics and living close together to attend the same school. As more schools are available in a given municipality, the more local (and the more homogeneous) the pool of students of any of the schools becomes. The case of primary students (grades 1 to 4) is the most salient regarding the combination of these two factors.

The persistent and stable non-null median segregation levels (over more than a decade as we document here) point to a situation of long-run equilibrium. As documented in this study, some time-invariant factors help explain this situation (e.g. school catchment areas, different granularities of different networks of schools, or first tracking age). Nonetheless, persistent preferences/pedagogical beliefs relative to what constitutes the optimal placement of students (between and within-schools) from both parents and schools’ authorities may also explain such time consistency of segregation patterns. Indeed, Levy & Razin’s (2017) theoretical framework predicts, in particular, the possibility of persistent between-school segregation patterns due to parents’ (possibly incorrect) beliefs. In this view, the case of 5<sup>th</sup> to 9<sup>th</sup> graders with differing academic abilities subject to a somewhat more uneven placement within-schools should again be highlighted. It is difficult to match it to any institutional feature (course tracking only kicks

in by grade 10) other than the vagueness of central regulations regarding class composition, quite probably filled in by the “optimal” behavior of local parents and, above all in this example, of local school authorities.<sup>28</sup>

In turn, two patterns emerged on how different minority shares and different segregation phenomena relate with each other (after netting-out several confounding factors). On one hand, municipalities with increasingly larger shares of low-income students tend to also be municipalities where low-income students are more evenly distributed across schools. On the other hand, there is a mild positive association between academic and economic segregation, at both between and within-school levels (extending the same pattern found at the country level in OECD, 2019). Although far from unity, this positive correlation can be viewed as potentially regressive because it means low-income and low-achieving pupils are more likely exposed to negative peer effects from others like them, whereas wealthier and high-achieving ones are more likely exposed to positive peer influences from others alike.

Our segregation estimates for the comparable segregation dimensions and populations of students are 20 to 35 p.p. lower than what had earlier been estimated by Bêa (2018), indicating that student segregation in Portugal, though non-null and persistent, is not as intense as thought until now. In line with this, our estimates place median student between-school economic segregation in Portugal on the lower end of what has been estimated across inner London local authorities (Allen et al., 2015; same segregation index), and below that of countries such as Brazil (Bartholo, 2013) and possibly Spain (Murillo & Martínez-Garrido, 2018). However, these two latter comparisons must be interpreted cautiously as they stem from different segregation metrics. Taking the insights of the NYC case of Conger (2005), our estimates of immigrant segregation (15% for both between and within-school cases) may be lower bounds to true racial/ethnic student segregation in Portugal. As in Conger (2005) we also conclude that between and within-school immigrant segregation levels have equal magnitudes.

It would be interesting to expand the current segregation analysis to other minority student populations not considered here – namely, taking into account private schools’ students and pupils enrolled in different tracks (e.g. vocational/professional tracks). One may also look at other students’ characteristics such as race/ethnicity (if made available in the future), or specialize those presented here (e.g. to look at the distribution of students with specific places of origin such as Brazil, Africa, and Eastern Europe). We leave these for future research.

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<sup>28</sup> We emphasize that we *do not* conclude the observed segregation patterns *per se* have benefited or hampered students’ in any particular way. We *do* conclude, however, that some segregation patterns exist (and have been stable over time), and given the accumulated evidence on broad peer effects discussed in Section 2, they may very well impact students in some fashion. Within-school segregation patterns, in particular, should be of special concern, especially those driven by local agents’ behaviors (as in this case). Specifically, whenever particular interests (e.g. preferences toward certain classes’ compositions from teachers or parents with greater bargaining power within the school) may not align with those of the *whole* local community of students.



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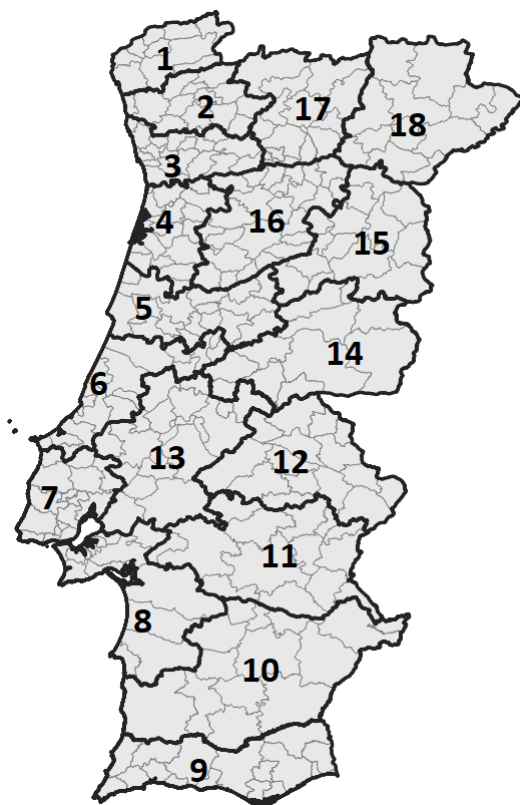
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## Appendix A

Map A1 – Administrative division of continental Portugal.



### List of Districts (Region):

- 1 – Viana do Castelo (North)
- 2 – Braga (North)
- 3 – Porto (Porto)
- 4 – Aveiro (North)
- 5 – Coimbra (Alentejo & Center)
- 6 – Leiria (Alentejo & Center)
- 7 – Lisboa (Lisboa+)
- 8 – Setúbal (Lisboa+)
- 9 – Faro (Algarve)
- 10 – Beja (Alentejo & Center)
- 11 – Évora (Alentejo & Center)
- 12 – Portalegre (Alentejo & Center)
- 13 – Santarém (Alentejo & Center)
- 14 – Castelo Branco (Alentejo & Center)
- 15 – Guarda (North)
- 16 – Viseu (North)
- 17 – Vila Real (North)
- 18 – Bragança (North)

Notes: The larger administrative divisions are the districts (thick black borders), while the smaller are the municipalities (faint grey borders). Each district is composed of several municipalities (15 on average). We define five regions – North, Porto, Alentejo & Center, Lisboa+, and Algarve – encompassing contiguous districts in order to simplify the exposition of some results.

Table A1 - Organization of the Portuguese public education system.

Grades	1	2	3	4	5	6	7	8	9	10	11	12
Modal Age (at beginning of grade)	6	7	8	9	10	11	12	13	14	15	16	17
Cycles (adopted names)	1 <sup>st</sup> Cycle (Primary)				2 <sup>nd</sup> Cycle (Upper-Primary)		3 <sup>rd</sup> Cycle (Lower-Secondary)			4 <sup>th</sup> Cycle (Upper-Secondary)		
ISCED (2011)	Level 1 - Primary Education						Level 2 - Lower Secondary Education			Level 3 - Upper Secondary Education		
Types of Schools	Type-1						Type-2					
							Type-3					
										Type-4		
										Type-5		

Table A2 – Proportions of students enrolled in regular academic track and public schools

		2006/07	2016/17
% students enrolled in regular academic track	cycle 1 (grades 1-4)	99,9	99,4
	cycle 2 (grades 5-6)	98,9	95,8
	cycle 3 (grades 7-9)	90,4	88,1
	cycle 4 (grades 10-12)	66,8	53,0
% students enrolled in public schools (among regular academic track students)	cycle 1 (grades 1-4)	89,5	87,3
	cycle 2 (grades 5-6)	87,7	86,5
	cycle 3 (grades 7-9)	88,0	87,0
	cycle 4 (grades 10-12)	88,9	86,0

Notes: figures derived by authors based on official statistics from Estatísticas da Educação 06/07 (DGEEC) and Estatísticas da Educação 2016/2017 (DGEEC). The universe is the set of students enrolled in continental Portugal schools.

Table A3 – Well Defined Cases of Between-School Economic Segregation

Economic	Original Sample	Share Complying With Restriction (i)	Share Complying With Restriction (ii)	Share Complying With Restriction (iii)	Share Complying With Restriction (iv)	Share Complying With Restrictions (i) - (iv) Lost Due To Restrictions (v) and (vi)	Restricted Sample	Percentage of Municipality-Grade-Years with Well Defined Segregation Measure
Total	34865	79	62	76	83	0.5	13507	39
Porto	2374	98	94	87	91	0.3	1807	76
Setúbal	1713	93	88	95	83	0.4	1216	71
Lisboa	2016	90	85	91	81	0.2	1324	66
Faro	1942	85	73	86	92	0.9	1107	57
Aveiro	2488	86	84	78	77	0.5	1317	53
Braga	1835	90	83	74	87	0.2	969	53
Santarém	2752	77	59	80	79	0.3	1031	37
Vila Real	1707	89	51	83	91	0.0	604	35
Viana do Castelo	1305	83	50	84	87	0.0	452	35
Leiria	1950	80	59	72	81	1.0	597	31
Coimbra	2170	70	62	67	75	0.8	633	29
Viseu	2959	79	50	79	83	0.7	832	28
Beja	1660	63	47	65	82	0.3	347	21
Castelo Branco	1393	61	40	61	83	0.4	276	20
Évora	1723	71	44	70	82	1.0	297	17
Portalegre	1619	51	38	53	85	0.8	244	15
Guarda	1795	70	40	68	86	1.1	267	15
Bragança	1464	74	30	72	83	2.1	187	13
Grade								
1	2944	66	82	40	73	0.0	705	24
2	2938	71	83	45	75	0.0	847	29
3	2933	70	83	45	74	0.0	836	29
4	2947	71	83	46	76	4.3	829	28
5	3027	92	55	94	97	0.0	1612	53
6	3028	92	55	95	97	1.5	1588	52
7	3040	92	60	95	98	0.0	1759	58
8	3041	87	60	93	96	0.0	1718	56
9	3041	84	60	92	94	0.3	1660	55
10	2647	82	37	94	82	0.0	777	29
11	2639	73	37	92	72	0.0	657	25
12	2640	67	37	90	62	0.0	519	20
School Year								
2006/07	3074	65	63	75	59	1.5	924	30
2007/08	3114	69	62	75	64	0.8	979	31
2008/09	3118	86	62	76	91	0.6	1263	41
2009/10	3133	85	62	76	91	0.8	1316	42
2010/11	3178	84	62	77	90	1.0	1315	41
2011/12	3198	78	62	78	82	0.9	1244	39
2012/13	3211	80	62	77	85	0.1	1274	40
2013/14	3205	82	61	77	88	0.1	1276	40
2014/15	3204	83	61	77	90	0.1	1305	41
2015/16	3214	81	61	76	89	0.0	1306	41
2016/17	3216	80	61	76	87	0.0	1305	41

Notes: the restricted sample refers to all the municipality-grade-years that comply with the following restrictions: (i) 10 or more low-income students; (ii) 2 or more schools; (iii) average school size of at least 30 students; (iv) share of low-income students between 10 and 90 percent; (v) share of students with missing information with respect to low-income status at most 10%; and (vi) percentile 80 (over the distribution of schools belonging to the municipality-grade-year) of share of students with missing information with respect to low-income status at most 20%. The restricted sample is then the set of municipality-grade-years' cases considered to have well defined between-school economic segregation.

Table A4 – Well Defined Cases of Between-School Academic Segregation

Academic	Original Sample	Share Complying With Restriction (i)	Share Complying With Restriction (ii)	Share Complying With Restriction (iii)	Share Complying With Restriction (iv)	Share Complying With Restrictions (i) - (iv) Lost Due To Restrictions (v) and (vi)	Restricted Sample	Percentage of Municipality-Grade-Years with Well Defined Segregation Measure
Total	34865	75	62	76	78	0.5	12878	37
District	Setúbal	1713	88	95	85	0.4	1210	71
	Porto	2374	92	94	87	1.1	1553	65
	Lisboa	2016	94	85	91	0.0	1283	64
	Aveiro	2488	86	84	77	0.5	1356	55
	Faro	1942	77	73	86	0.1	997	51
	Braga	1835	86	83	74	0.2	906	49
	Santarém	2752	77	59	80	0.6	987	36
	Leiria	1950	75	59	72	0.4	689	35
	Vila Real	1707	69	51	83	0.0	529	31
	Coimbra	2170	72	62	67	0.3	672	31
	Viseu	2959	71	50	79	0.3	792	27
	Viana do Castelo	1305	70	50	68	0.3	309	24
	Beja	1660	63	47	65	0.6	358	22
	Castelo Branco	1393	58	40	61	2.2	266	19
	Évora	1723	70	44	70	1.8	276	16
	Portalegre	1619	48	38	53	0.0	246	15
	Guarda	1795	59	40	68	0.0	255	14
	Bragança	1464	62	30	72	2.0	194	13
	1	2944	8	82	40	0	0	0
	2	2938	52	83	45	1.2	324	11
	3	2933	59	83	45	0.9	574	20
	4	2947	66	83	46	1.2	747	25
Grade	5	3027	83	55	92	0.1	1521	50
	6	3028	87	55	95	0.2	1609	53
	7	3040	91	60	95	0.0	1781	59
	8	3041	88	60	93	0.0	1764	58
	9	3041	89	60	92	0.0	1747	57
	10	2647	93	37	94	1.7	946	36
	11	2639	92	37	92	1.5	934	35
	12	2640	92	37	90	1.3	931	35
	2006/07	3074	80	63	75	1.0	1191	39
	2007/08	3114	78	62	75	0.8	1196	38
	2008/09	3118	77	62	76	0.5	1177	38
	2009/10	3133	74	62	76	0.3	1169	37
School Year	2010/11	3178	74	62	76	0.3	1160	37
	2011/12	3198	73	62	78	0.6	1131	35
	2012/13	3211	74	62	77	0.3	1148	36
	2013/14	3205	74	61	77	0.5	1170	37
	2014/15	3204	74	61	77	0.4	1190	37
	2015/16	3214	72	61	76	0.3	1173	36
	2016/17	3216	72	61	76	0.3	1173	36

Notes: the restricted sample refers to all the municipality-grade-years that comply with the following restrictions: (i) 10 or more students with at least 1 retention; (ii) 2 or more schools; (iii) average school size of at least 30 students; (iv) share of students with at least 1 retention between 10 and 90 percent; (v) share of students with missing information with respect to having at least 1 retention at most 10%; and (vi) percentile 80 (over the distribution of schools belonging to the municipality-grade-year) of share of students with missing information with respect to having at least 1 retention at most 20%. The restricted sample is then the set of municipality-grade-years' cases considered to have well defined between-school academic segregation.



Table A5 – Well Defined Cases of Between-School Immigrant Segregation

Immigrant	Original Sample	Share Complying With Restriction (i)	Share Complying With Restriction (ii)	Share Complying With Restriction (iii)	Share Complying With Restriction (iv)	Share Complying With Restrictions (i) - (iv) Lost Due To Restrictions (v) and (vi)	Restricted Sample	Percentage of Municipality-Grade-Years with Well Defined Segregation Measure
Total	34865	60	62	76	54	1.4	8907	26
District	Setúbal	1713	88	95	83	1.3	1243	73
	Lisboa	2016	93	91	89	1.7	1462	73
	Faro	1942	81	73	93	1.6	1140	59
	Leiria	1950	70	73	73	1.9	608	31
	Santarém	2752	59	59	54	0.9	796	29
	Aveiro	2488	81	84	71	1.2	718	29
	Viana do Castelo	1305	78	84	71	0.9	341	26
	Vila Real	1707	48	51	62	2.1	429	25
	Coimbra	2170	50	62	50	1.8	379	17
	Viseu	2959	45	50	51	1.2	502	17
	Castelo Branco	1393	49	40	63	1.3	236	17
	Guarda	1795	44	40	74	0.8	254	14
	Bragança	1464	38	30	72	2.6	191	13
	Braga	1835	74	83	27	0.0	214	12
	Porto	2374	90	94	8	0.0	181	8
	Beja	1660	28	47	33	1.0	100	6
	Portalegre	1619	23	38	23	0.0	55	3
	Évora	1723	23	44	17	0.0	58	3
	1	2944	52	82	50	0.2	501	17
Grade	2	2938	55	83	51	0.2	585	20
	3	2933	57	83	53	0.0	617	21
	4	2947	57	83	53	5.6	589	20
	5	3027	63	55	55	0.1	969	32
	6	3028	64	55	56	1.6	972	32
	7	3040	65	60	57	0.2	1071	35
	8	3041	62	60	56	0.3	1035	34
	9	3041	61	60	55	1.3	1001	33
	10	2647	68	37	57	1.2	563	21
	11	2639	61	37	54	2.1	523	20
	12	2640	58	37	51	6.6	481	18
School Year	2006/07	3074	58	63	49	7.1	667	22
	2007/08	3114	60	62	52	3.3	741	24
	2008/09	3118	61	62	54	1.7	809	26
	2009/10	3133	62	62	55	1.3	848	27
	2010/11	3178	63	62	57	0.9	871	27
	2011/12	3198	62	62	57	0.8	880	28
	2012/13	3211	61	62	56	0.7	856	27
	2013/14	3205	61	61	55	0.1	837	26
	2014/15	3204	59	61	54	0.1	809	25
	2015/16	3214	58	61	53	0.0	801	25
	2016/17	3216	57	61	52	0.0	788	25

Notes: the restricted sample refers to all the municipality-grade-years that comply with the following restrictions: (i) 10 or more immigrant students; (ii) 2 or more schools; (iii) average school size of at least 30 students; (iv) share of immigrant students between 10 and 90 percent; (v) share of students with missing information with respect to immigrant status at most 10%; and (vi) percentile 80 (over the distribution of schools belonging to the municipality-grade-year) of share of students with missing information with respect to immigrant status at most 20%. The restricted sample is then the set of municipality-grade-years' cases considered to have well defined between-school immigrant segregation.

Table A6 – Well Defined Cases of Within-School Economic Segregation

Economic	Original Sample	Share Complying With Restriction (i)	Share Complying With Restriction (ii)	Share Complying With Restriction (iii)	Share Complying With Restriction (iv)	Share Complying With Restrictions (i) - (iv) Lost Due To Restrictions (v) and (vi)	Restricted Sample	Percentage of School-Grade-Years with Well Defined Segregation Measure
Total	68605	78	95	99	84	0.3	49820	73
Vila Real	2018	89	94	99	94	0.1	1732	86
Porto	10544	89	97	100	90	0.1	8909	84
Braga	5263	87	97	99	88	0.3	4352	83
Viana do Castelo	1917	82	93	99	92	0.7	1519	79
Viseu	3549	80	96	99	92	0.1	2751	78
Faro	3589	81	94	97	90	0.6	2782	78
Setúbal	5332	82	98	99	81	0.1	3929	74
Lisboa	11644	82	98	98	78	0.5	8489	73
Aveiro	5165	77	96	99	83	0.3	3744	72
Leiria	3014	75	97	100	82	0.2	2052	68
Bragança	1382	72	89	99	87	0.5	931	67
Santarém	3526	68	96	99	80	0.1	2195	62
Guarda	1780	66	88	99	90	0.0	1108	62
Castelo Branco	1850	62	87	99	84	0.2	1064	58
Évora	1570	63	92	99	79	0.1	890	57
Coimbra	3288	60	90	98	76	0.4	1797	55
Beja	1755	53	88	99	80	0.2	873	50
Portalegre	1419	53	82	98	85	0.0	703	50
1								
2								
3								
4								
5	9199	87	96	99	94	0.0	7873	86
6	9178	88	96	99	94	0.8	7810	85
7	11346	84	96	100	91	0.0	9236	81
8	11396	77	95	100	88	0.0	8468	74
9	11362	72	94	99	85	1.0	7701	68
10	5418	77	94	98	76	0.0	3524	65
11	5369	68	93	98	66	0.0	2885	54
12	5337	60	94	96	57	0.0	2323	44
2006/07	6072	63	97	99	64	0.5	3365	55
2007/08	6180	67	96	99	70	0.3	3691	60
2008/09	6240	80	96	98	87	0.4	4661	75
2009/10	6274	84	96	99	90	0.5	4982	79
2010/11	6285	82	96	99	88	0.4	4846	77
2011/12	6343	77	95	99	84	0.2	4517	71
2012/13	6322	80	95	99	86	0.2	4712	75
2013/14	6250	81	95	99	88	0.2	4779	76
2014/15	6231	82	94	99	90	0.1	4806	77
2015/16	6212	81	93	99	89	0.1	4740	76
2016/17	6196	81	93	99	90	0.1	4721	76

Notes: the restricted sample refers to all the school-grade-years that comply with the following restrictions: (i) 10 or more low-income students; (ii) 2 or more classes; (iii) average class size between 10 and 30 (including); (iv) share of low-income students between 10 and 90 percent; (v) share of students with missing information with respect to low-income status at most 10%; and (vi) percentile 80 (over the distribution of classes belonging to the school-grade-year) of share of students with missing information with respect to low-income status at most 20%. The restricted sample is then the set of school-grade-years' cases considered to have well defined within-school economic segregation. Cases of school-grade-years referring to grades 1 through 4 were not considered due to incidence of mixed-grade classes during primary schooling, see Section 5 for details.

Table A7 – Well Defined Cases of Within-School Academic Segregation

Academic	Original Sample	Share Complying With Restriction (i)	Share Complying With Restriction (ii)	Share Complying With Restriction (iii)	Share Complying With Restriction (iv)	Share Complying With Restrictions (i) - (iv) Lost Due To Restrictions (v) and (vi)	Restricted Sample	Percentage of School-Grade-Years with Well Defined Segregation Measure
Total	68605	84	95	99	99	0.8	55905	81
District	Setúbal	96	98	99	97	1.1	4978	93
	Lisboa	95	98	98	94	1.2	10590	91
	Porto	91	97	100	90	0.6	9200	87
	Faro	87	94	97	93	0.4	3089	86
	Leiria	84	97	100	93	0.2	2497	83
	Santarém	84	96	99	93	1.3	2884	82
	Aveiro	84	96	99	89	0.9	4198	81
	Évora	83	92	99	92	0.6	1268	81
	Braga	83	97	99	86	0.1	4133	79
	Vila Real	78	94	99	88	0.5	1527	76
	Viseu	76	96	99	90	0.5	2643	74
	Coimbra	73	90	98	85	0.6	2334	71
	Beja	71	88	99	87	0.7	1223	70
	Bragança	1382	89	99	84	1.9	935	68
	Castelo Branco	68	87	99	83	0.9	1226	66
	Viana do Castelo	1917	93	99	78	1.2	1251	65
	Guarda	64	88	99	83	0.7	1108	62
	Portalegre	1419	82	98	80	1.1	821	58
Grade	1							
	2							
	3							
	4							
	5	9199	96	99	83	0.3	6685	73
	6	9178	96	99	91	0.2	7479	81
	7	11346	96	100	91	0.2	9497	84
	8	11396	95	100	90	0.0	9188	81
	9	11362	94	99	91	1.3	9102	80
	10	5418	94	98	93	2.2	4697	87
	11	5369	93	98	93	1.9	4633	86
	12	5337	94	96	93	1.7	4624	87
School Year	2006/07	93	97	99	96	1.1	5514	91
	2007/08	6180	96	99	95	1.0	5422	88
	2008/09	6240	96	98	93	0.8	5262	84
	2009/10	6274	96	99	92	0.8	5203	83
	2010/11	6285	96	99	90	0.6	5084	81
	2011/12	6343	95	99	88	0.7	4975	78
	2012/13	6322	95	99	90	0.9	5136	81
	2013/14	6250	95	99	89	0.6	5039	81
	2014/15	6231	94	99	88	0.9	4851	78
	2015/16	6212	93	99	86	0.8	4727	76
	2016/17	6196	93	99	86	0.5	4692	76

Notes: the restricted sample refers to all the school-grade-years that comply with the following restrictions: (i) 10 or more students with at least 1 retention; (ii) 2 or more classes; (iii) average class size between 10 and 30 (including); (iv) share of students with at least 1 retention between 10 and 90 percent; (v) share of students with missing information with respect to having at least 1 retention at most 10%; and (vi) percentile 80 (over the distribution of classes belonging to the school-grade-year) of share of students with missing information with respect to having at least 1 retention at most 20%. The restricted sample is then the set of school-grade-years' cases considered to have well defined within-school academic segregation. Cases of school-grade-years referring to grades 1 through 4 were not considered due to incidence of mixed-grade classes during primary schooling, see Section 5 for details.

Table A8 – Well Defined Cases of Within-School Immigrant Segregation

Immigrant	Original Sample	Share Complying With Restriction (i)	Share Complying With Restriction (ii)	Share Complying With Restriction (iii)	Share Complying With Restriction (iv)	Share Complying With Restrictions (v) and (vi)	Restricted Sample	Percentage of School-Grade-Years with Well Defined Segregation Measure
Total	68605	53	95	99	57	3.3	29121	42
District	Setúbal	84	98	99	87	3.7	4144	78
	Lisboa	11644	98	98	89	5.6	9006	77
	Faro	3589	94	97	90	3.8	2556	71
	Leiria	3014	62	100	73	2.8	1653	55
	Viana do Castelo	1917	59	93	68	1.2	1013	53
	Vila Real	2018	45	94	67	1.8	850	42
	Santarém	3526	47	96	55	1.1	1390	39
	Guarda	1780	39	88	76	1.2	669	38
	Aveiro	5165	46	96	46	1.3	1813	35
	Bragança	1382	36	89	68	2.7	473	34
	Viseu	3549	37	96	56	1.2	1174	33
	Coimbra	3288	38	90	49	1.5	1024	31
	Castelo Branco	1850	37	87	58	0.7	568	31
	Braga	5263	39	97	28	0.3	1055	20
	Porto	10544	33	97	16	0.7	1282	12
	Évora	1570	20	92	20	0.6	164	10
	Beja	1755	15	88	35	2.2	180	10
	Portalegre	1419	14	82	20	0.0	107	8
1								
2								
3								
4								
Grade	5	55	96	99	57	0.9	4183	45
	6	9178	55	96	57	3.2	4077	44
	7	11346	51	96	57	1.8	5018	44
	8	11396	46	95	57	2.0	4650	41
	9	11362	44	94	56	5.7	4205	37
	10	5418	67	94	59	3.2	2609	48
	11	5369	61	93	56	4.9	2317	43
	12	5337	58	94	53	7.2	2062	39
	2006/07	6072	47	97	48	11.9	1994	33
	2007/08	6180	49	96	52	7.5	2297	37
	2008/09	6240	52	96	55	5.3	2518	40
	2009/10	6274	54	96	58	3.3	2747	44
School Year	2010/11	6285	56	96	60	2.5	2867	46
	2011/12	6343	55	95	59	1.5	2900	46
	2012/13	6322	55	95	59	1.4	2905	46
	2013/14	6250	54	95	57	1.2	2786	45
	2014/15	6231	52	94	58	0.9	2746	44
	2015/16	6212	51	93	57	1.2	2680	43
	2016/17	6196	51	93	57	1.4	2681	43

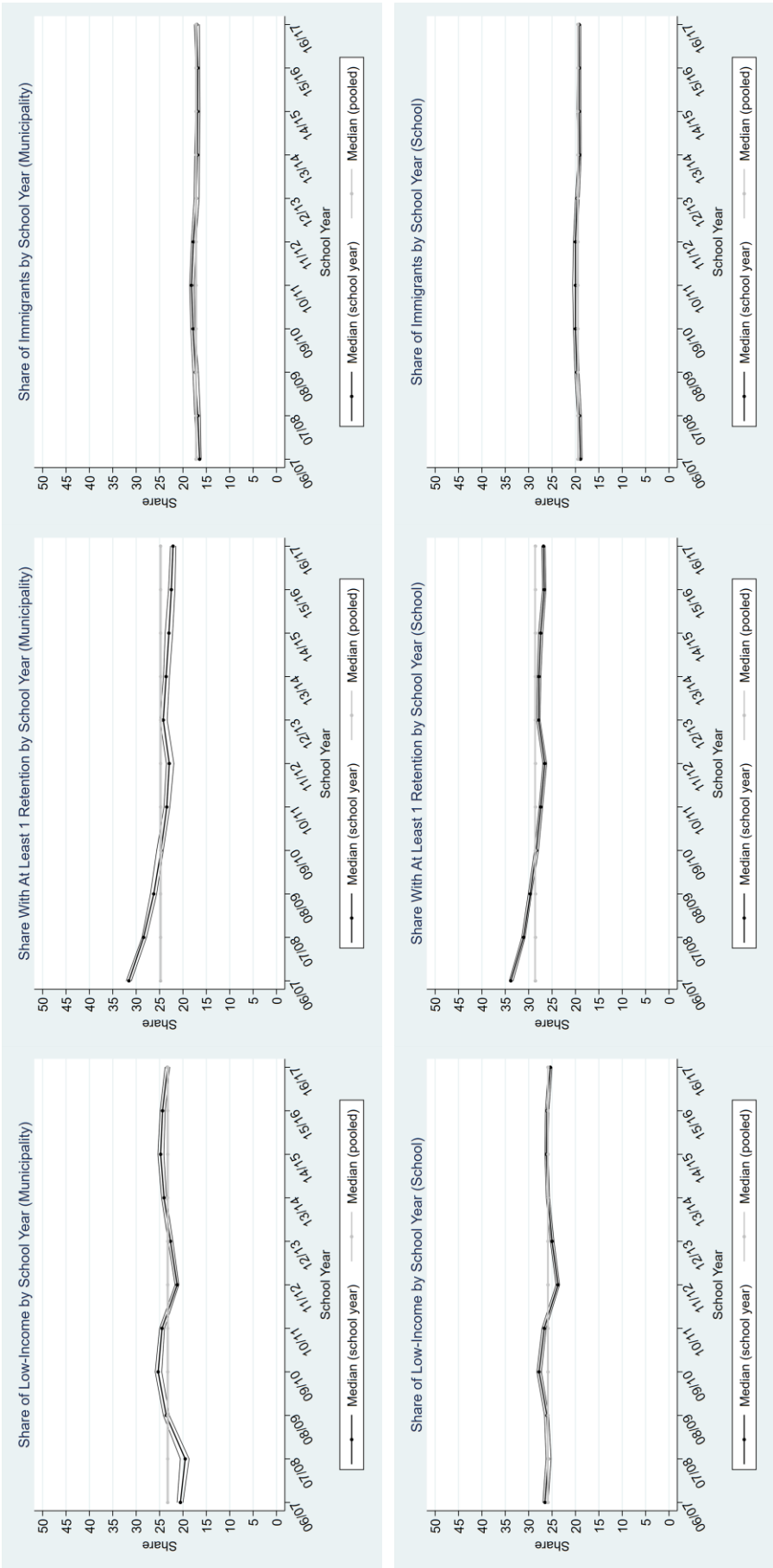
Notes: the restricted sample refers to all the school-grade-years that comply with the following restrictions: (i) 10 or more immigrant students; (ii) 2 or more classes; (iii) average class size between 10 and 30 (including); (iv) share of immigrant students between 10 and 90 percent; (v) share of students with missing information with respect to immigrant status at most 10%; and (vi) percentile 80 (over the distribution of classes belonging to the school-grade-year) of share of students with missing information with respect to immigrant status at most 20%. The restricted sample is then the set of school-grade-years' cases considered to have well defined within-school immigrant segregation. Cases of school-grade-years referring to grades 1 through 4 were not considered due to incidence of mixed-grade classes during primary schooling, see Section 5 for details.

Table A9 – Segregation and Minority Proportion Correlation Matrix (excluding variables related to immigrant status)

Residual Partial Correlations (N = 26,503)		Municipality						School					
		Segregation			Population Share			Segregation			Population Share		
		Immig. Back.	Economic	Academic	Immig. Back.	Low Income	1 Retention	Immig. Back.	Economic	Academic	Immig. Back.	Low Income	1 Retention
Municipality	Immig. Back.												
	Economic		1										
	Academic		<b>0.21*</b>	1									
	Immig. Back.												
	Low Income		<b>-0.28*</b>	0.02*		1							
	1 Retention		0.04*	0.00		0.12*	1						
School	Immig. Back.												
	Economic		0.01*	-0.01		0.01	0.01		1				
	Academic		0.01	0.01		0.00	0.02*		<b>0.20*</b>	1			
	Immig. Back.												
	Low Income		0.17*	-0.01		<b>0.39*</b>	-0.05*		-0.06*	0.01		1	
	1 Retention		-0.02*	0.07*		-0.08*	<b>0.31*</b>		0.00	0.07*		<b>0.32*</b>	1

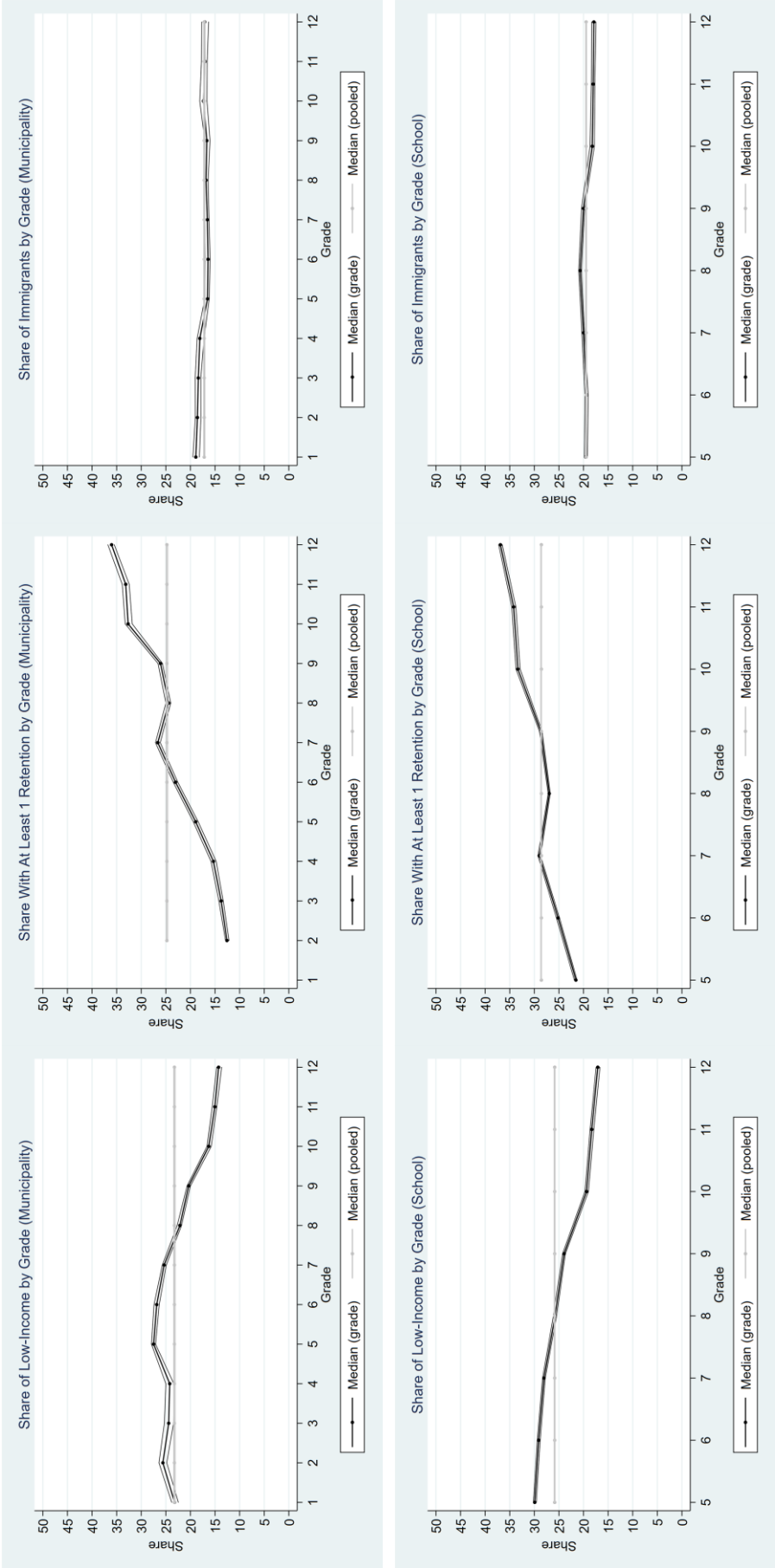
Notes: This correlation matrix is the result of a two-stage procedure. In the first stage municipality (school), school-year, and grade fixed effects were partialled-out from each municipality (school) level variable present in the matrix. In the second stage a partial correlation matrix was computed using the residuals from the first stage. This way, the partial correlations shown here report the level of (linear) association between any pair of variables beyond the confounding influences of municipality (school), school-year, and grade specificities, as well as, holding fixed all the other variables present in the matrix. Partial correlations greater than or equal to 0.2 (in absolute value) are bold emphasized, and those with \* are statistically significant at 5% level.

Figure A1 – Minority Shares Over Time



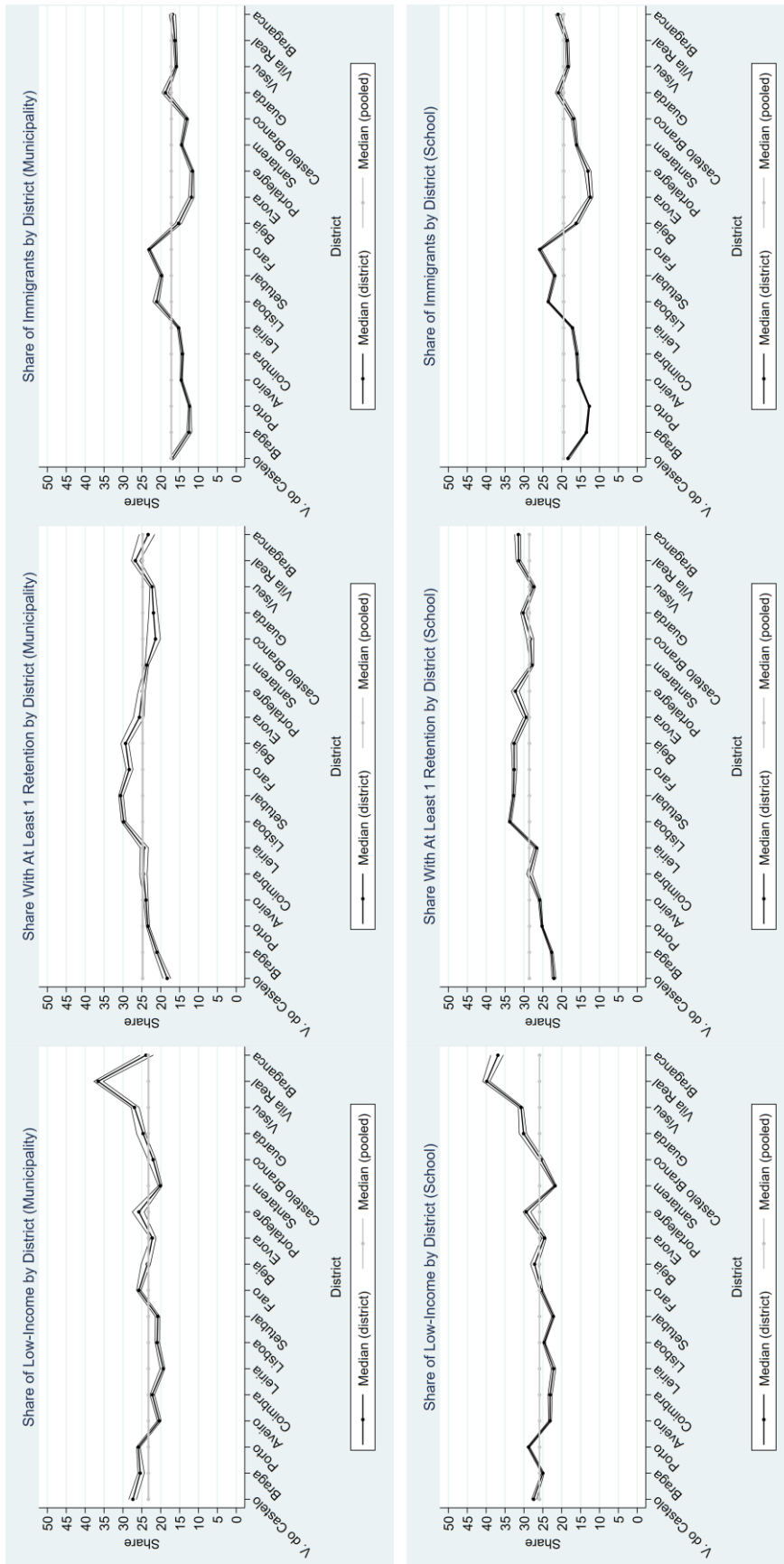
Notes: Each black dot represents the median share of a given minority. The median is taken from the distribution obtained by pooling all unit-grade-years that (i) are cases of well-defined segregation\*, and that (ii) share the same horizontal axis category. "Unit" is either municipality (first row plots), or school (second row plots). Each grey dot represents the median share taken from the overall pool of unit-grade-years that are cases of well-defined segregation, hence constant across horizontal axis categories. All medians' point estimates have 95% confidence intervals. \*As explained in the text, for within-school measures we only consider the school-grade-year cases whose grade is different from primary schooling (i.e. different from grades 1 through 4), so only those cases are pooled either overall or for each horizontal axis category (second row plots). The particular plot of the share of the academic minority (with at least 1 retention) does not consider municipality-1-year cases, that is 1<sup>st</sup> grade cases, as there are no retentions during this grade (thus medians stem from distributions pooling all cases except these).

Figure A2 – Minority Shares Across Grades



Notes: Each black dot represents the median share of a given minority. The median is taken from the distribution obtained by pooling all unit-grade-years that (i) are cases of well-defined segregation\*, and that (ii) share the same horizontal axis category. "Unit" is either municipality (first row plots), or school (second row plots). Each grey dot represents the median share taken from the overall pool of unit-grade-years that are cases of well-defined segregation, hence constant across horizontal axis categories. All medians' point estimates have 95% confidence intervals. \*As explained in the text, for within-school measures we only consider the school-grade-year cases whose grade is different from primary schooling (i.e. different from grades 1 through 4), so only those cases are pooled either overall or for each horizontal axis category (second row plots). The particular plot of the share of the academic minority (with at least 1 retention) does not consider municipality-1-year cases, that is 1<sup>st</sup> grade cases, as there are no retentions during this grade (thus medians stem from distributions pooling all cases except these).

Figure A3 – Minority Shares Across Districts



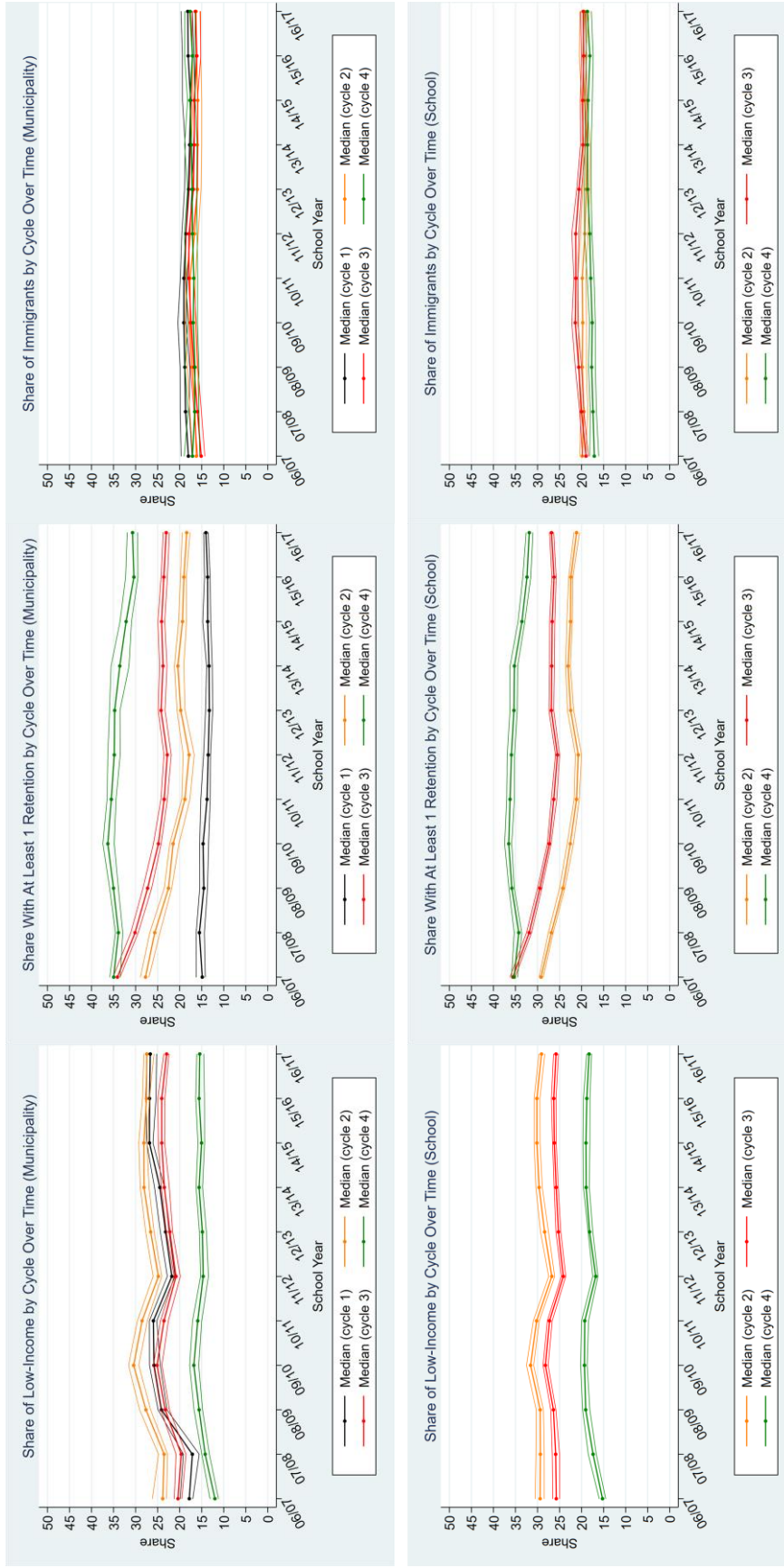
Notes: Each black dot represents the median share of a given minority. The median is taken from the distribution obtained by pooling all unit-grade-years that (i) are cases of well-defined segregation\*, and that (ii) share the same horizontal axis category. "Unit" is either municipality (first row plots), or school (second row plots).<sup>\*\*</sup> Each grey dot represents the median share taken from the overall pool of unit-grade-years that are cases of well-defined segregation, hence constant across horizontal axis categories. All medians' point estimates have 95% confidence intervals.

\* As explained in the text, for within-school measures we only consider the school-grade-year cases whose grade is different from primary schooling (i.e. different from grades 1 through 4), so only those cases are pooled either overall or for each horizontal axis category (second row plots). The particular plot of the share of the academic minority (with at least 1 retention) does not consider municipality-1-year cases, that is 1st grade cases, as there are no retentions during this grade (thus medians stem from distributions pooling all cases except these).

\*\* Districts only work as a reference to pool the unit-grade-years cases for which the "unit" (either a municipality or a school) happens to belong to a particular district.

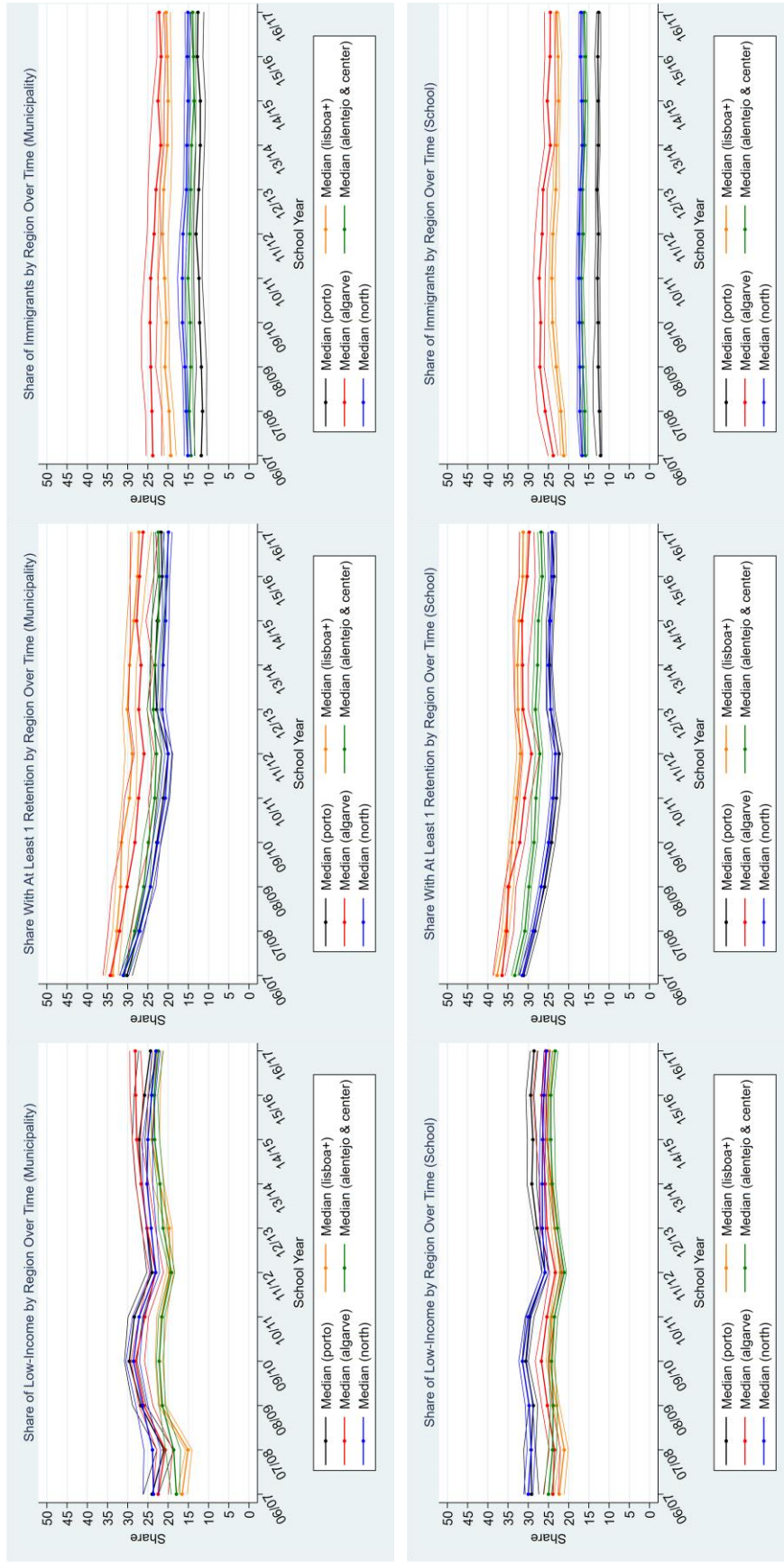


Figure A4 – Minority Shares by Cycle Over Time



Notes: Each black dot represents the median share of a given minority. The median is taken from the distribution obtained by pooling all unit-grade-years that (i) are cases of well-defined segregation\*, and that (ii) share the same horizontal axis category. "Unit" is either municipality (first row plots), or school (second row plots). Each grey dot represents the median share taken from the overall pool of unit-grade-years that are cases of well-defined segregation, hence constant across horizontal axis categories. All medians' point estimates have 95% confidence intervals. Cycles group unit-grade-year cases that belong to specific grades: 1<sup>st</sup> cycle (primary schooling) – grades 1 through 4; 2<sup>nd</sup> cycle – grades 5 and 6; 3<sup>rd</sup> cycle – grades 7 through 9; 4<sup>th</sup> cycle (upper-secondary) – grades 10 through 12. \*As explained in the text, for within-school measures we only consider the school-grade-year cases whose grade is different from primary schooling (i.e. different from grades 1 through 4), so only those cases are pooled either overall or for each horizontal axis category (second row plots). The particular plot of the share of the academic minority (with at least 1 retention) does not consider municipality-1-year cases, that is 1st grade cases, as there are no retentions during this grade (thus medians stem from distributions pooling all cases except these).

Figure A5 – Minority Shares Across Regions Over Time

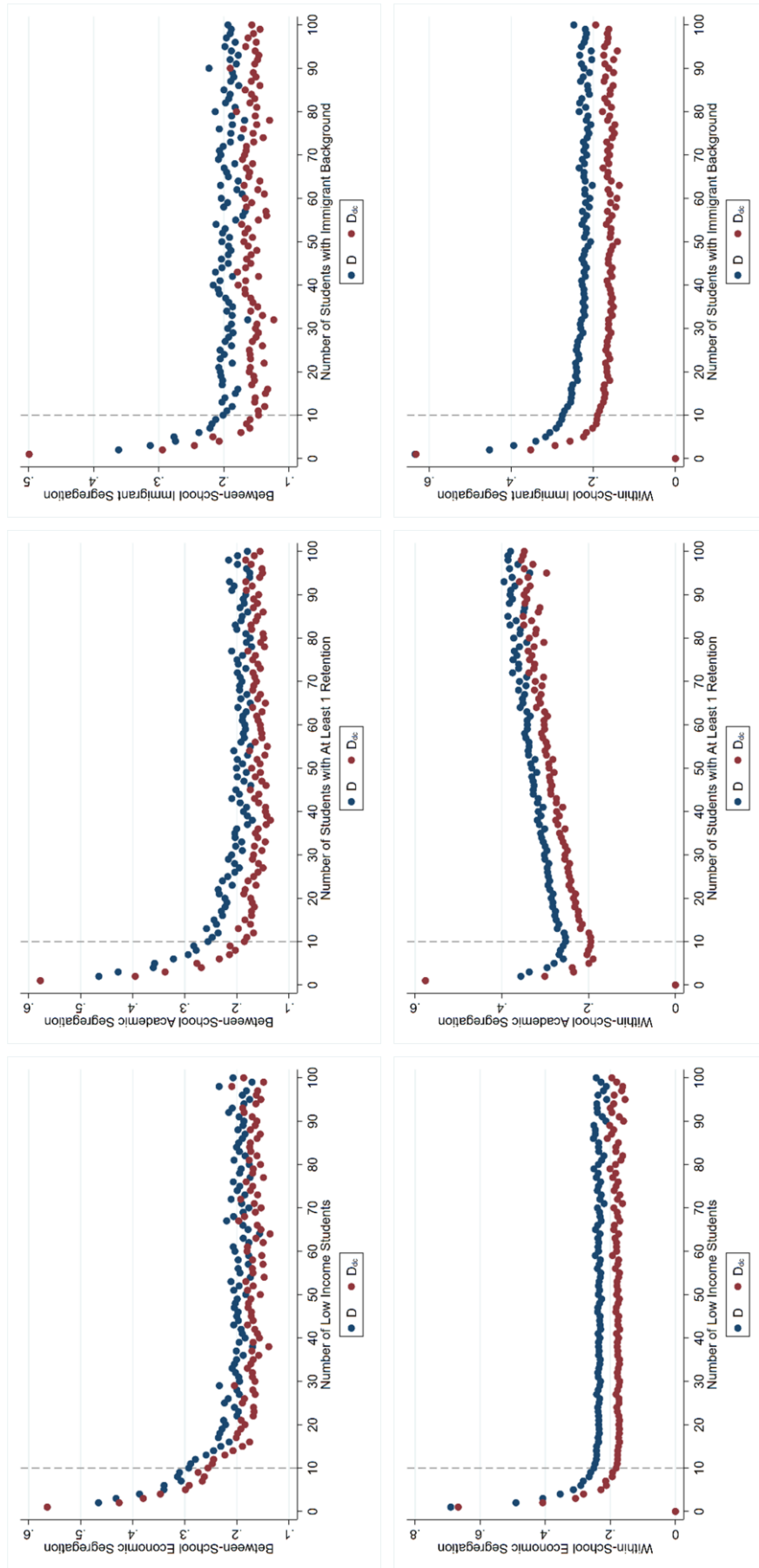


Notes: Each black dot represents the median share of a given minority. The median is taken from the distribution obtained by pooling all unit-grade-years that (i) are cases of well-defined segregation<sup>\*</sup>, and that (ii) share the same horizontal axis category. "Unit" is either municipality (first row plots), or school (second row plots).<sup>\*\*</sup> Each grey dot represents the median share taken from the overall pool of unit-grade-years that are cases of well-defined segregation, hence constant across horizontal axis categories. All medians' point estimates have 95% confidence intervals.<sup>†</sup>

<sup>\*</sup>As explained in the text, for within-school measures we only consider the school-grade-year cases whose grade is different from primary schooling (i.e. different from grades 1 through 4), so only those cases are pooled either overall or for each horizontal axis category (second row plots). The particular plot of the share of the academic minority (with at least 1 retention) does not consider municipality-1-year cases, that is 1st grade cases, as there are no retentions during this grade (thus medians stem from distributions pooling all cases except these).

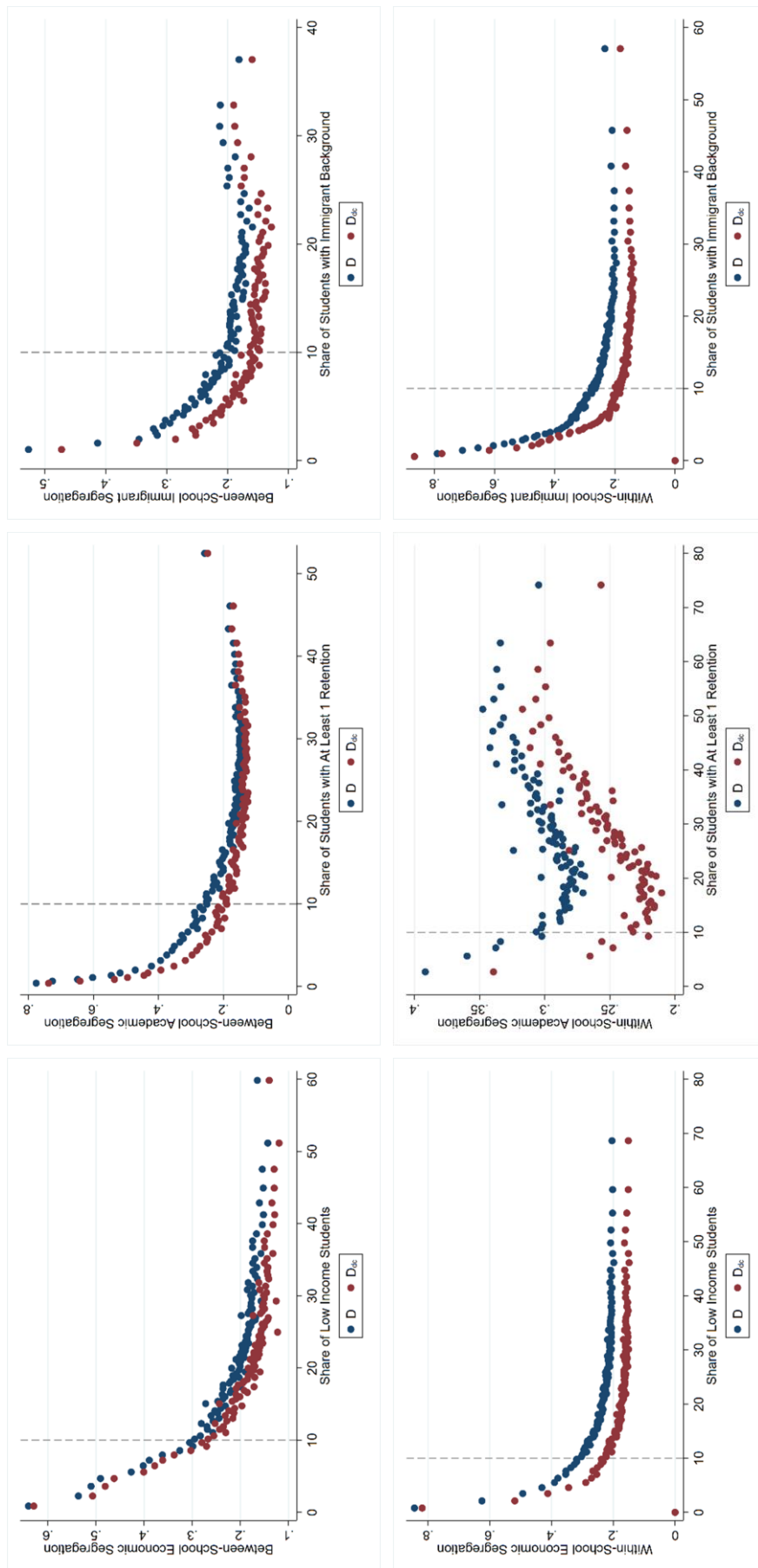
<sup>\*\*</sup>Regions only work as a reference to pool the unit-grade-year cases for which the "unit" (either a municipality or a school) happens to belong to a particular region. In turn, "regions" group districts: "porto" – Porto; "lisboa+" – Lisboa and Setúbal; "algarve" – Faro; "alentejo & center" – Beja, Évora, Portalegre, Santarém, Leiria, Coimbra, and Castelo Branco; "north" – Viana do Castelo, Braga, Vila Real, Bragança, Guarda, Viseu, and Aveiro.

Figure A6 – Number of Minority Students and Index Inflation



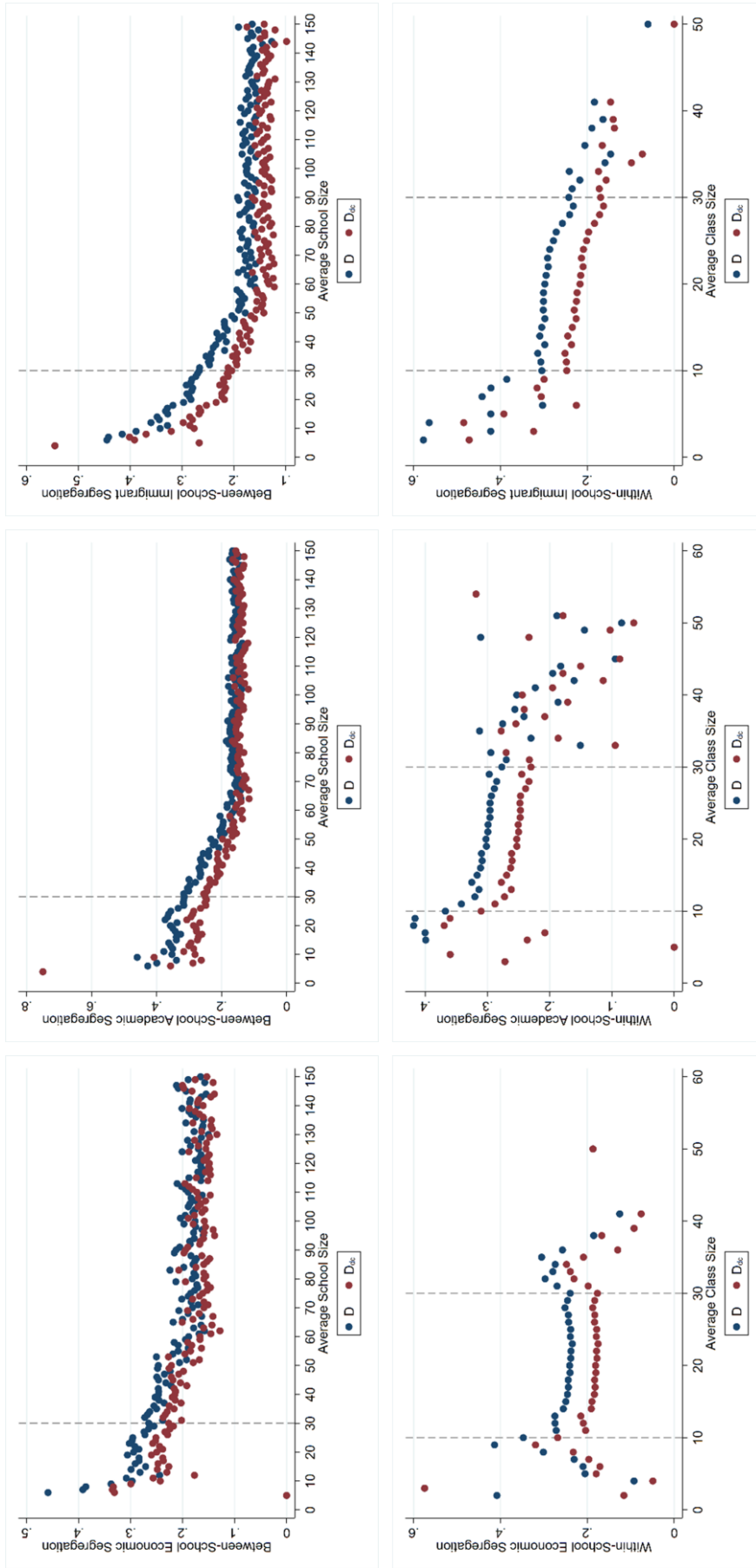
Notes: the number of minority students are at the municipality and school levels, for between and within-school segregations measures, respectively. Each scatterplot plots the average segregation as measured by the classic index (D) and by the density corrected index (D<sub>ec</sub>), in which the average is taken for all cases with the same value of the horizontal axis (Stata command: binscatter, see Stepner, 2013). The horizontal axis was trimmed at 100 for ease of graphical exposition.

Figure A7 – Share of Minority Students and Index Inflation



Notes: the share of minority students are at the municipality and school levels, for between and within-school segregations measures, respectively. Each scatterplot plots the average segregation as measured by the classic index ( $D$ ) and by the density corrected index ( $D_{dc}$ ), in which the average is taken for all cases with the same value of the horizontal axis (Stata command: binscatter, see Stepner, 2013).

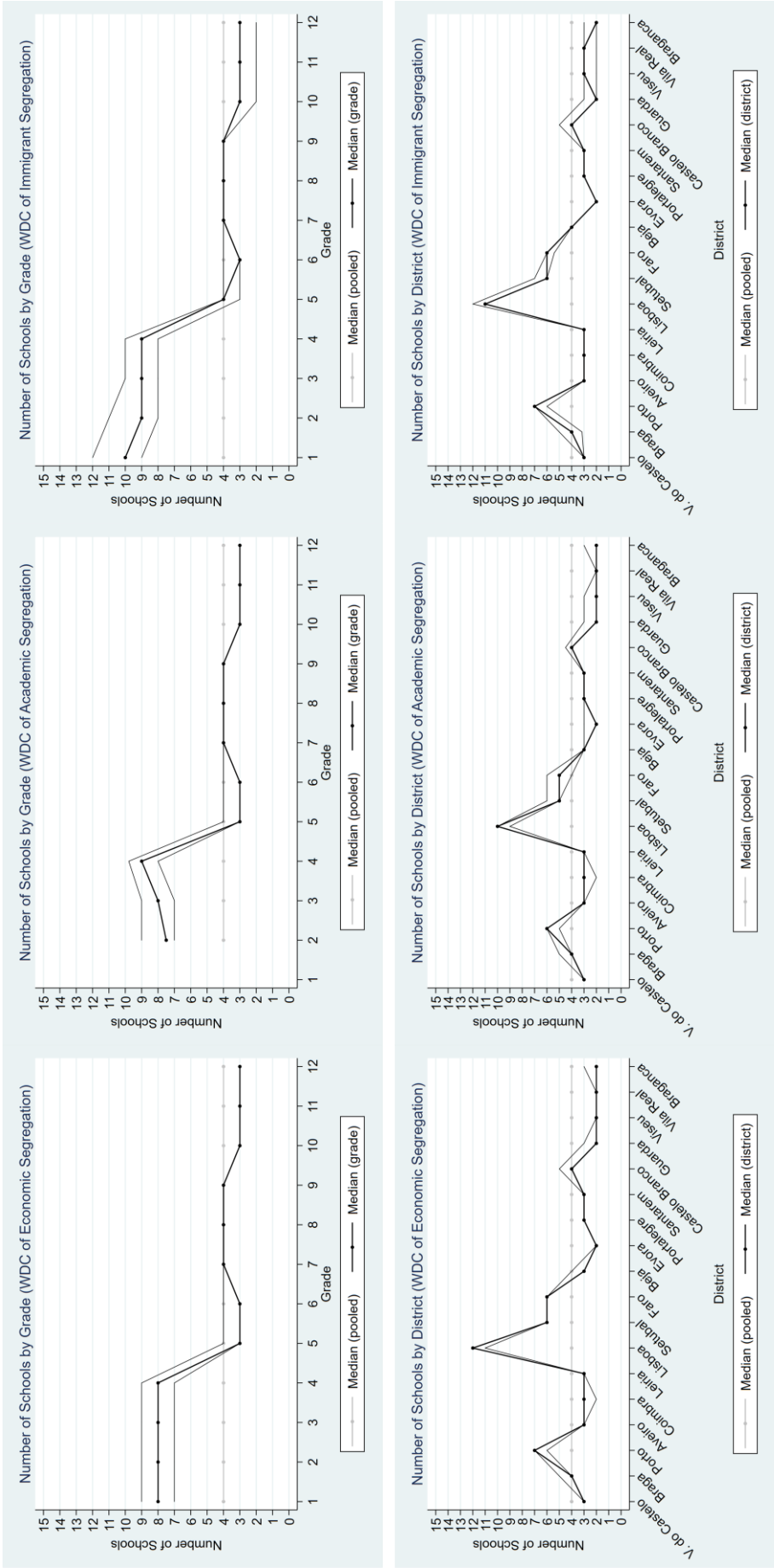
Figure A8 – Average Unit Sizes and Index Inflation



Notes: the average unit sizes refer to schools at the municipality level and to classes at the school level, for between and within-school segregations measures, respectively. Each scatterplot plots the average segregation as measured by the classic index (D) and by the density corrected index (D<sub>dc</sub>), in which the average is taken for all cases with the same value of the horizontal axis (Stata command: binscatter, see Stepner, 2013). The horizontal axis, on first row plots, was trimmed at 150 for ease of graphical exposition.



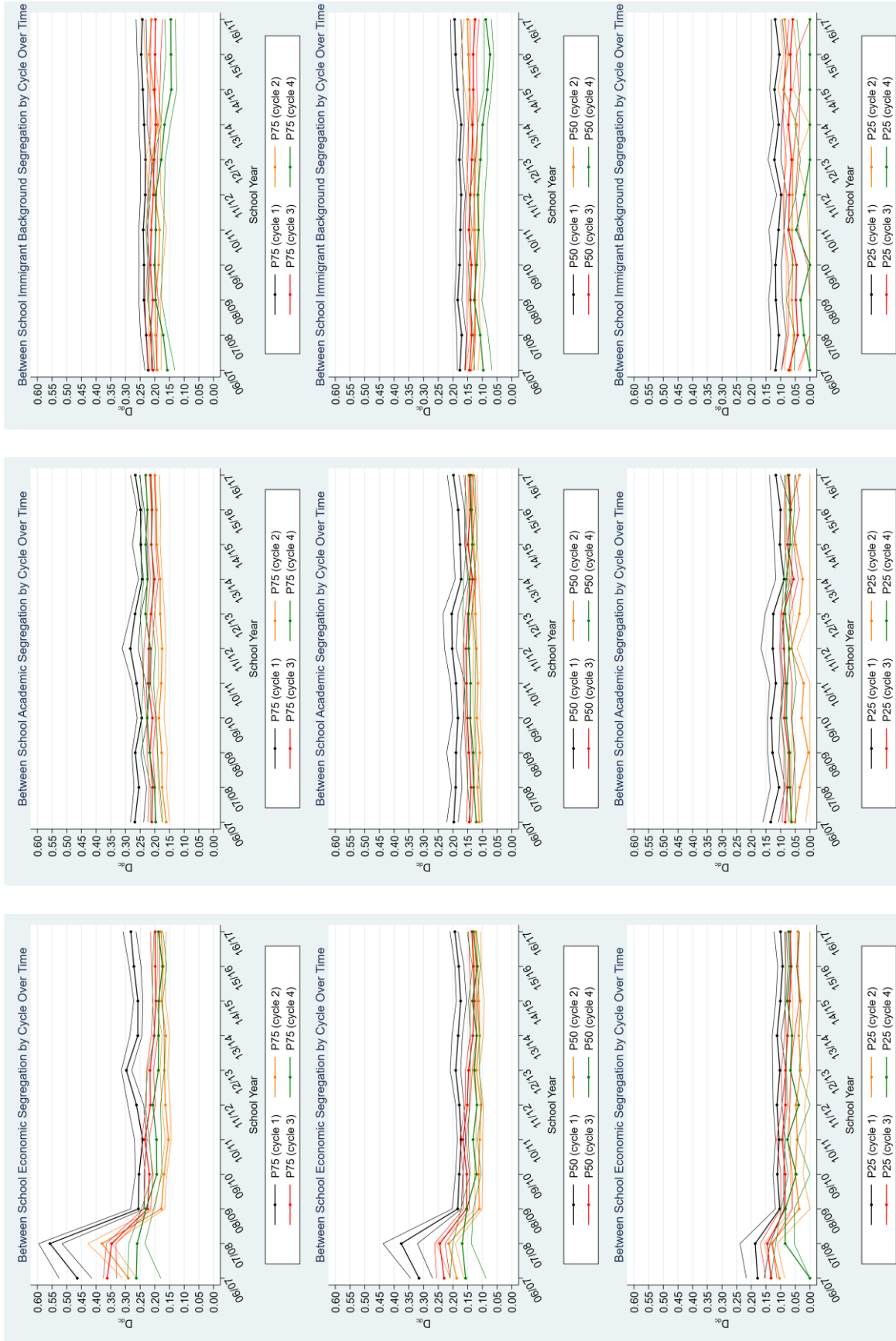
Figure A9 – Number of Schools for Each Sample of Well-Defined Cases (WDC) of Segregation (across grades and districts)



Notes: Each black dot represents the median number of schools. The median is taken from the distribution obtained by pooling all municipality-grade-years that (i) are cases of well-defined segregation\*, and that (ii) share the same horizontal axis category. Each grey dot represents the median number of schools taken from the overall pool of municipality-grade-years that are cases of well-defined segregation, hence constant across horizontal axis categories. All medians' point estimates have 95% confidence intervals.

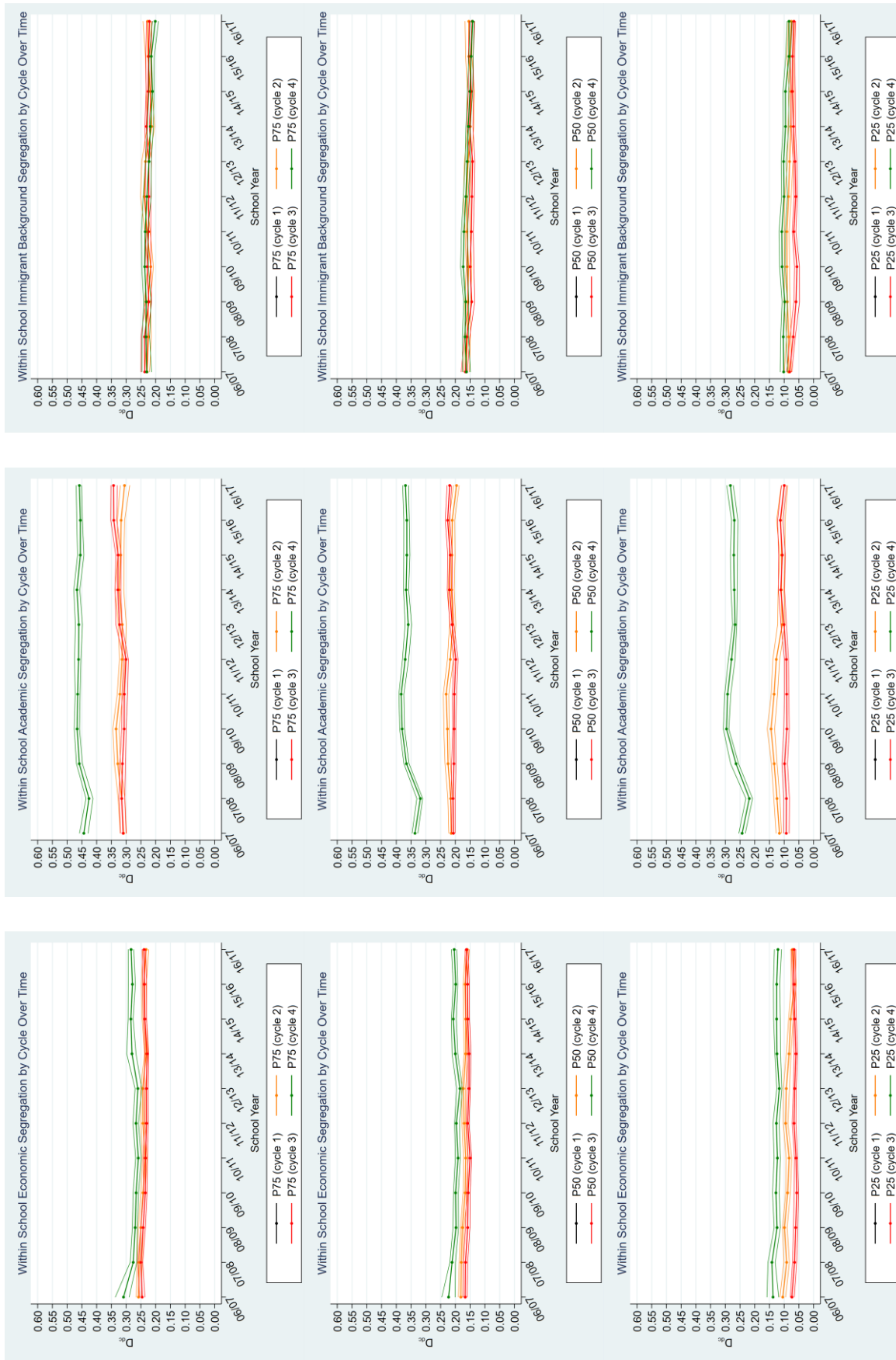
\* The particular plot of number of schools for well-defined cases of academic segregation does not consider municipality-1-year cases, that is 1<sup>st</sup> grade cases, as there are no retentions during this grade (thus medians stem from distributions pooling all cases except these).

Figure A10 – Between School Segregation By Cycle Over Time (25<sup>th</sup>, 50<sup>th</sup>, and 75<sup>th</sup> Percentiles)



Notes: All series represent estimates of segregation as measured by the density corrected dissimilarity index ( $D_{dc}$ ). P25, P50, and P75 (connected lines) correspond to percentiles 25, 50 (median), and 75, respectively, from the distribution obtained by pooling all municipality-grade-years that (i) are cases of well-defined segregation\*, and that (ii) share the same horizontal axis category. All point estimates have 95% confidence intervals. Cycles group unit-grade-year cases that belong to specific grades: 1<sup>st</sup> cycle (primary schooling) – grades 1 through 4; 2<sup>nd</sup> cycle – grades 5 and 6; 3<sup>rd</sup> cycle – grades 7 through 9; 4<sup>th</sup> cycle (upper-secondary) – grades 10 through 12.  
\* The plots of between-school academic segregation do not consider municipality-1-year cases, that is 1<sup>st</sup> grade cases, as there are no retentions during this grade (thus percentiles stem from distributions pooling all cases except these).

Figure A11 – Within School Segregation By Cycle Over Time (25<sup>th</sup>, 50<sup>th</sup>, and 75<sup>th</sup> Percentiles)



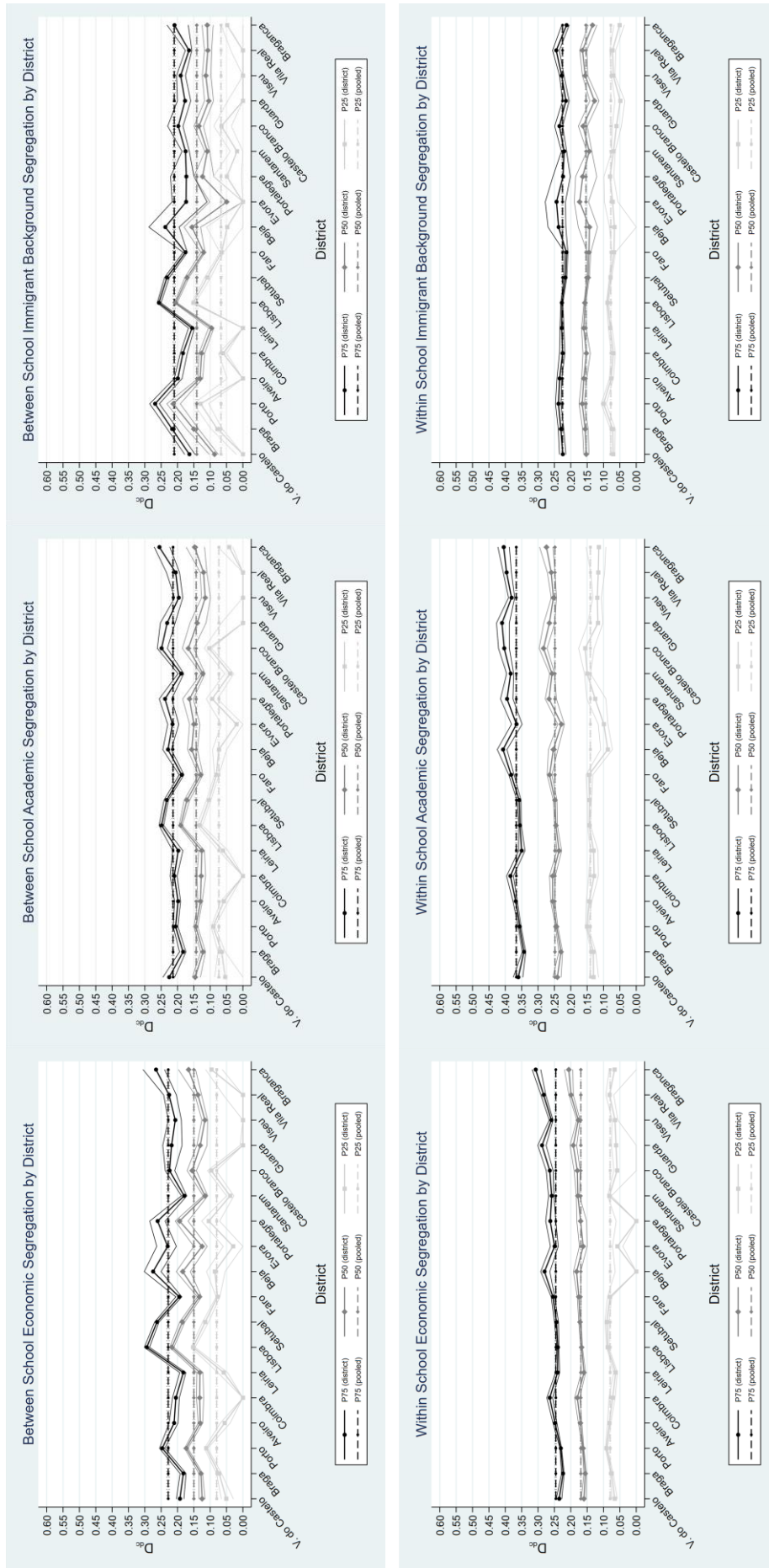
Notes: All series represent estimates of segregation as measured by the density corrected dissimilarity index ( $D_{dc}$ ). P25, P50, and P75 (connected lines) correspond to percentiles 25, 50 (median), and 75, respectively, from the distribution obtained by pooling all school-grade-years that (i) are cases of well-defined segregation\*, and that (ii) share the same horizontal axis category. All point estimates have 95% confidence intervals. Cycles group unit-grade-year cases that belong to specific grades: 1<sup>st</sup> cycle (primary schooling) – grades 1 through 4; 2<sup>nd</sup> cycle – grades 5 and 6; 3<sup>rd</sup> cycle – grades 7 through 9; 4<sup>th</sup> cycle (upper-secondary) – grades 10 through 12.

\*As explained in the text, for within-school measures we only consider the school-grade-year cases whose grade is different from primary schooling (i.e. different from grades 1 through 4).



## Appendix B – Segregation Estimates by District

Figure B1 – Segregation Across Districts



Notes: All series represent estimates of segregation as measured by the density corrected dissimilarity index ( $D_w$ ). P25, P50, and P75 (connected lines) correspond to percentiles 25, 50 (median), and 75, respectively, from the distribution obtained by pooling all unit-grade-years that (i) are cases of well-defined segregation\*, and that (ii) share the same horizontal axis category. "Unit" is municipality for between-school segregation measures (first row plots), and school for within-school ones (second row plots).\*\* P25, P50, and P75 (dashed lines) represent percentiles 25, 50 (median), and 75 taken from the overall pool of unit-grade-years that are cases of well-defined segregation, hence constant across horizontal axis categories. All point estimates have 95% confidence intervals.

\*As explained in the text, for within-school measures we only consider the school-grade-year cases whose grade is different from primary schooling (i.e. different from grades 1 through 4), so only those cases are pooled either overall or for each horizontal axis category. The particular plot of between-school academic segregation does not consider municipality-1-year cases, that is 1<sup>st</sup> grade cases, as there are no retentions during this grade (thus percentiles stem from distributions pooling all cases except these).

\*\*Districts only work as a reference to pool the unit-grade-years cases for which the "unit" (either a municipality or a school) happens to belong to a particular district.

Regional differences are more pronounced in terms of between-school segregation rather than within. Figure B1 depicts the six segregation-districts profiles where districts work only as a reference to pool the unit-grade-year cases for which the “unit” (either a municipality or a school) happens to belong to. Lisboa and Setúbal districts show the highest levels of median between-school segregation across all three dimensions, around 17% to 21%. Porto district attains between-school segregation levels that are above the overall median with respect to economic and immigrant segregation (just as Lisboa and Setúbal), but not with respect to academic segregation. The lowest levels of median between-school economic segregation are found in northern and central districts such as Viana do Castelo, Braga, Aveiro, Santarém, and Viseu (around 12-13%).<sup>29</sup>

In turn, schools that are closer to having the fair shares of the municipality immigrant students are mainly found in northern districts: Viana do Castelo, Leiria (center, not northern), Évora (even considering its wide confidence interval; south-center, not northern), Guarda, Viseu, Vila Real, and Bragança. Notice that as mentioned in Section 5, these districts tend to house immigrant students born in countries that are usually targets of Portuguese emigration and whose parents (or at least one of them) were actually born in Portugal. It is, in fact, in the districts that tend to house relatively more immigrants whose origin is either from Brazil, Africa (Portuguese-speaking countries), or Eastern Europe, that between-school segregation is higher: Lisboa, Porto, and Setúbal. Faro district (which has a considerable share of municipality-grade-years considered to be well-defined cases of immigrant segregation, almost as high as the districts of Lisboa and Setúbal, see Table A5, as well as the largest median share of immigrants across its municipality-grade-years, almost 25%, see top right graph of Figure A3) is the exception according to Figure B1 (top right graph), as its immigrant students tend to also be of the latter type and yet they are less segregated across schools there than their counterparts of Lisboa, Porto, and Setúbal.<sup>30</sup>

Finally, the interquartile ranges of all series presented in Figure B1 also revolve around 15 p.p., but again that of within-school academic segregation is the largest (20 p.p.).

The general findings relative to between-school segregation confirm and expand those obtained in Justino et al. (2017) and Baptista & Pereira (2018), namely that the levels of economic and (as now advanced here) of academic and immigrant between-school segregation tend to be greater in districts whose municipality-grade-years show a higher density of schools (comparing the top and bottom rows of Figures B1 and A9, respectively). Faro seems the only exception to this relationship, as it has a fair amount of schools, but lower levels of between-school segregation (across all three dimensions).

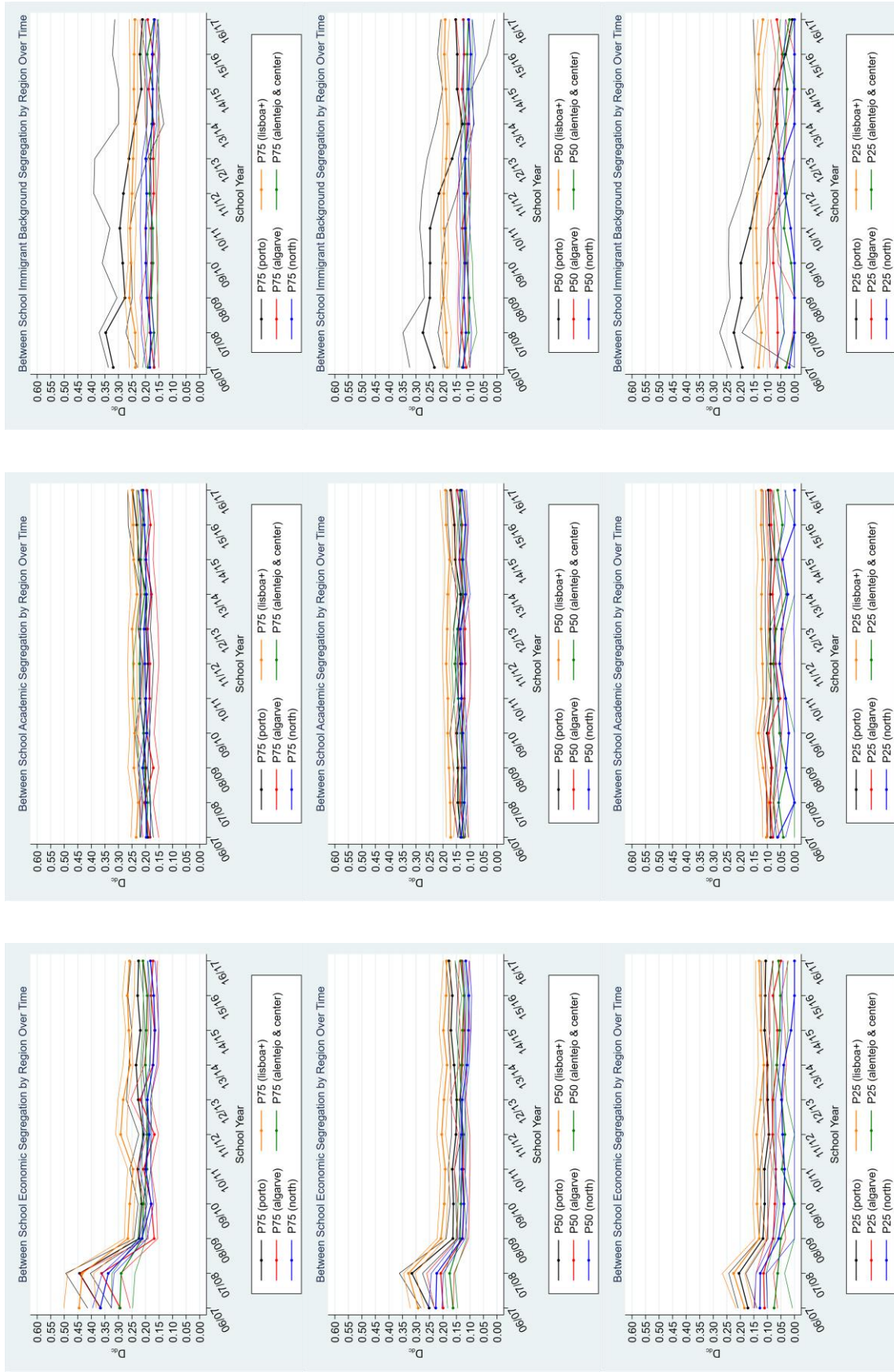
Figures B2 and B3 present the regional differences over time. The main insights discussed above seem to endure: higher median between-school segregation in the Lisboa-Setúbal region (Lisboa+) and almost no regional differences in terms of within-school segregation. Only two main new points: first, the series break of between-school economic segregation was felt more intensely for students living in municipalities located in the regions of Lisboa+ and Porto; second, the between-school immigrant segregation peak of Porto shown in Figure B1 (top right) seems to be

<sup>29</sup> Although low-income students seem to be almost equally distributed across schools within municipalities located in northern districts, it is in the schools of northern-most districts of Guarda, Vila Real, and Bragança that these students are more segregated within-schools, across classes. There, the corresponding median density-corrected index attains levels around 19-21%, which are slightly, but significantly, above the overall median of 17%.

<sup>30</sup> Note that Faro district has an immigrant share larger than that of Setúbal (Figure A3), and the same median number of schools as Setúbal (Figure A9). Still, Faro’s between-school immigrant segregation levels are visibly lower than those of Setúbal. This points to regional differences in between-school immigrant segregation patterns beyond those that can be related to differences in minority share and school network granularity.

somewhat driven by higher median segregation levels during the first half of the period analyzed (the confidence interval is quite large though, as just a very small portion of Porto's municipality-grade-years correspond to cases of well-defined between-school immigrant segregation, see Table A5).

Figure B2 – Between School Segregation Across Regions Over Time (25<sup>th</sup>, 50<sup>th</sup>, and 75<sup>th</sup> Percentiles)



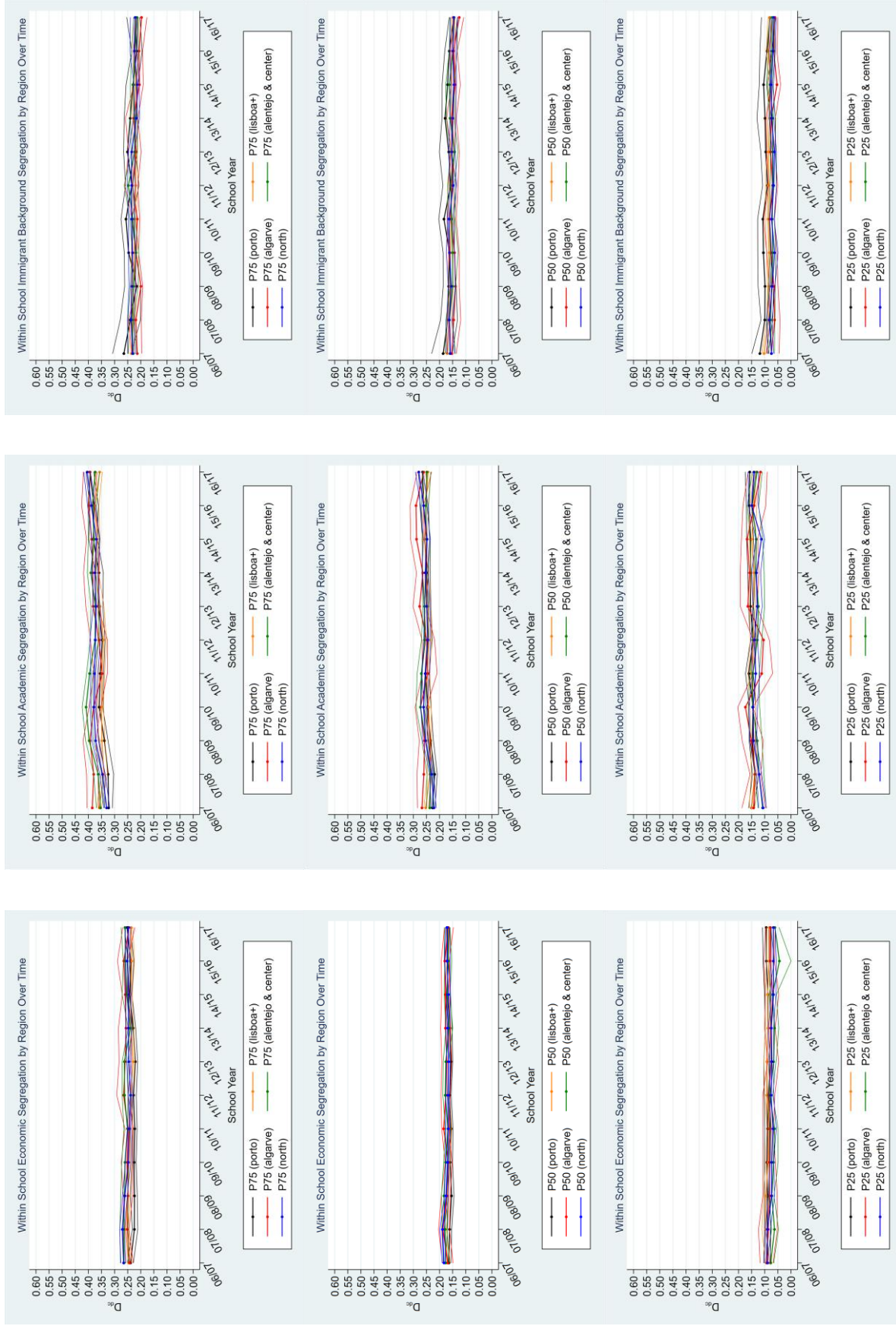
Notes: All series represent estimates of segregation as measured by the density corrected dissimilarity index ( $D_{dc}$ ). P25, P50, and P75 (connected lines) correspond to percentiles 25, 50 (median), and 75, respectively, from the distribution obtained by pooling all municipality-grade-years that (i) are cases of well-defined segregation<sup>\*</sup>, and that (ii) share the same horizontal axis category. All point estimates have 95% confidence intervals.

<sup>\*</sup> The plots of between-school academic segregation do not consider municipality-1-year cases, as there are no retentions during this grade (thus percentiles stem from distributions pooling all cases except these).

<sup>\*\*</sup>Regions only work as a reference to pool the municipality-grade-year cases that happen to belong to a particular region. In turn, “regions” group districts: “porto” – Porto; “lisboa+” – Lisboa and Setúbal; “algarve” – Faro; “alentejo & center” – Beja, Évora, Portalegre, Santarém, Leiria, Coimbra, and Castelo Branco; “north” – Viana do Castelo, Braga, Vila Real, Bragança, Guarda, Viseu, and Aveiro.



Figure B3 – Within School Segregation Across Regions Over Time (25<sup>th</sup>, 50<sup>th</sup>, and 75<sup>th</sup> Percentiles)



Notes: All series represent estimates of segregation as measured by the density corrected dissimilarity index ( $D_{dc}$ ). P25, P50, and P75 (connected lines) correspond to percentiles 25, 50 (median), and 75, respectively, from the distribution obtained by pooling all school-grade-years that (i) are cases of well-defined segregation\*, and that (ii) share the same horizontal axis category. All point estimates have 95% confidence intervals.

\* As explained in the text, for within-school measures we only consider the school-grade-year cases whose grade is different from primary schooling (i.e. different from grades 1 through 4).

\*\*Regions only work as a reference to pool the school-grade-year cases that happen to belong to a particular region. In turn, "regions" group districts: "porto" – Porto; "lisboa+" – Lisboa and Setúbal; "algarve" – Faro; "alentejo & center" – Beja, Évora, Portalegre, Santarém, Leiria, Coimbra, and Castelo Branco; "north" – Viana do Castelo, Braga, Vila Real, Bragança, Guarda, Viseu, and Aveiro.

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